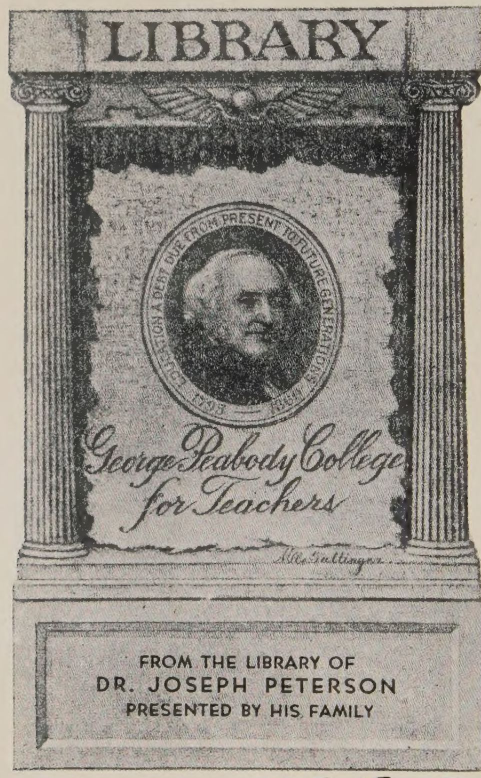
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PSYCHOLOGY FOR STUDENTS OF EDUCATION

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PSYCHOLOGY FOR STUDENTS OF EDUCATION

BY

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TO

G. S. G.

PREFACE

This book has been written to meet the needs of students of education who are seeking from psychology the facts and principles that have a bearing upon their problems. It is designed to serve both as a text for college and normal school courses and as a book for general reading by the student already engaged in professional service.

In selecting materials, I have been guided by the aim of presenting clearly and accurately the important principles of psychology with illustrations and applications that are of distinct significance in education. The outcome of this effort has been a departure in several respects from the usual introductory textbook of psychology. Perhaps the most conpicuous deviation is the omission or reduction of space devoted to some of the experimental and descriptive studies of the sensory processes and perception. The facts of color combinations, the theories of vision and audition, illusions, and the perception of time and movement are samples of topics that have been omitted entirely or relegated to a subordinate position. A brief account of the introspective analysis of the content of consciousness has been included, however, partly to give the student some familiarity with this field of research and partly to introduce portions of the technical vocabulary essential to the understanding of later sections and much of the suggested collateral reading. The various mental processes, such as perception, memory, and conception, are treated mainly as varieties of re-

actions and types of learning rather than as mental structures.

A relatively large amount of space and emphasis is given to the mechanics and dynamics of human nature for which much of the first part of the book is preparatory. The treatment of the receiving, connecting and reacting mechanisms, however, is schematic and brief. Attention is centered on the functions rather than the structures of these organs, and little is presented that does not bear upon the genuinely psychological problems that follow.

The investigations of learning in the case of the "higher" mental processes of analysis, abstraction or conception and reasoning are few, but the need of guidance in educational practice is here most keenly felt. My attempt to meet this need on the basis of available facts may have resulted in an impression of dogmatism. I have, however, preferred to state what seem to be the best solutions of the problems rather than to confuse the student with divergent views or to neglect important issues.

While the book has been written to satisfy the needs of students of education primarily, it may be found serviceable as an introductory text in general psychology, especially by those who wish to give a relatively large amount of time to the dynamics of human behavior and the more complex mental activities.

My obligations for assistance in the preparation of the book are heavy. To Professor E. L. Thorndike, I am indebted, not only for many suggestions for the revision of a first draft of the manuscript which he read, but for the wider influence of his teachings and writings that will be obvious throughout the book. I am grateful to Miss Eloise Boeker, Miss Donah Lithauer and Miss Dorothy

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ARTHUR I. GATES.

Teachers College,
Columbia University,
May, 1923.

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CHAPTER I

THE METHODS AND SUBJECT MATTER OF PSYCHOLOGY

By the use of methods similar to those employed in the natural sciences, psychology attempts to solve many of the problems concerning human behavior which have long been treated in less exact fashion. Teachers, physicians, lawyers, preachers, business executives, in fact, people in all walks of life attempt to understand, as best they may, by observing their own impulses, feelings, thoughts, and acts, as well as the behavior of others, the general characteristics of human conduct, and the peculiar traits of particular individuals. As a result of our observations, most of us have acquired notions concerning the motives which may be relied upon to stir us or others to action; concerning the acts and situations which please and displease; concerning the signs by which emotions and thoughts are made manifest. We have acquired methods of estimating traits of character such as honesty, sociability, ambitiousness, and traits of mind, such as alertness, depth, and sagacity. We have convictions concerning the relative mentality of men and women; concerning the temperaments of negroes and whites; concerning the learning capacity of children and adults. We have beliefs about the influence of the weather, fa-

tigue, or coffee upon efficiency in thought or skill. Long the subject of ordinary speculation, these problems and many similar ones when attacked by scientific methods constitute psychology.

The General Methods of Scientific Investigation

The Unreliability of Ordinary Observation.—Ordinary observation of human behavior is extremely untrustworthy and as a consequence personal opinions are likely to be incorrect. Several investigations, under conditions similar to those of actual life, have disclosed a fallibility of observation and report which seems almost incredible. For example, an act involving a quarrel was once carefully rehearsed, the stage photographed, the conversation memorized, and the brief scene then performed before a group of professional men. Thinking the quarrel real, and anticipating the use of their testimony in court, the witnesses wrote out a full report. Among the forty men, only one had observed and remembered as much as 80 per cent of the important facts, twenty-six had omitted from 20 to 50 per cent, and thirteen more than half. Besides these omissions, from 5 to 50 per cent of the statements were erroneous; some of them pure inventions.

That the surprise and emotional upset are not mainly responsible for such results has been frequently demonstrated by experiments upon witnesses who were aware of the artificiality of the scene. A section of a motion picture requiring about three minutes' time was shown to a group of college students who were familiar with the character of errors in such experiments. Following the display, a list of 60 questions concerning more or less obvious details were asked. From 10 to 40 per cent

were unanswered, and of the replies from 8 to 50 per cent were wrong. When the task is made even more simple by giving the subject an ordinary colored picture for a half minute of study, the reports still show glaring omissions and errors.

Methods of Increasing the Reliability of Observation. The unreliability of observation noted in such experiments is due partly to the subject's inexperience in the particular field, partly to the complexity of the events, and partly to their brevity. The scientific worker attempts to improve the conditions of observation in these three directions. First, he must secure training in perceiving the particular items of interest. Just as the physician must learn to detect with greater accuracy the physical signs of disease, the psychiatrist those of insanity, the teacher those of inattentiveness, as the result of continued practice, so in psychology the investigator must learn to observe his own mental states, the fleeting images of memory or imagination, the feeling content of anger, excitement or fear, or the qualities of organic sensations, as well as the eye-movements, facial expressions, vocalizations or other results of activity in other people. Although nearly every one has observed the eyes of others during the act of reading, few people have noticed with any precision the jerky, start and stop character of the movement of the eye as it follows the printed line. Even when attention is called to the eye-movements, they are not readily perceived at first, although after a period of practice they may be observed with considerable precision. Practice will greatly improve the accuracy and precision of observation along any line, hence the scientific method demands trained observers.

Observation becomes more effective when the facts to be considered are isolated and controlled. Isolation may

be secured partly as the result of training, inasmuch as one may learn to attend to certain facts while neglecting others. One reason for the incompleteness of observation and report in such experiments as those mentioned above, lay in the fact that attention was under no definite control, was guided by no particular question. The subjects observed in general. Attention must be specifically controlled and directed to the pertinent matters lest the observer be led astray by irrelevant details or place emphasis on the wrong facts.

The Conditions of an Experiment.—The facts of observation must be isolated in another sense, in the mechanical sense that the observer must control all of the conditions which may conceivably affect the factor under study. The character of the eye movements, for example, may vary according to the length of the line, the difficulty of the material, the size of the type, or the brightness of the illumination. Usually the subject, therefore, is seated in a room from which unusual light, sounds, and other distractions are excluded. The material to be read, the distance of the eyes from the copy, and all other factors which might affect the performance are controlled and reproduced when the experiment is repeated.

When the investigator is attempting to discover the causes and effects of an observed fact, it is especially important to isolate the fact and control all other factors. Thus, to ascertain the effect of the difficulty of reading material upon the character of the eye movements, it would be necessary to hold constant all of the factors—length of the line, size of type, illumination, fatigue, etc. —while the difficulty of the material alone varied in repeated tests. In studying the effects of ventilation on mental efficiency, subjects were kept in a room in which

temperature, movement of the air, humidity, the percentage of oxygen, and the percentage of expired matter could be mechanically and independently varied. Under these conditions, the specific effects of temperature could be determined by securing samples of work under different degrees of heat, while other factors were held constant. Similarly the influence of humidity or of other factors could be ascertained by varying each while all others are controlled.

Human subjects are played upon by so many forces and their adjustments to them are so subtle, that extraordinary care must be exercised to secure adequate control of the conditions. A business-college teacher had developed a system of teaching handwriting. It was urged that this system was better than any other because most of the pupils became unusually good writers. But the truth was that the unusual amount of time and relentless insistence on achievement rather than the merits of the system were responsible for the pupils' success. Causes can be determined only when all of the influences are taken into account. The writing system must be tried by many different teachers on many different classes and the results compared with those obtained from trials of other systems, when the length of practice, the skill of teachers, the initial ability and interest of the pupils, and other factors are equalized. Comparison of the school grades of students who smoke with the marks of non-smokers is usually of no scientific value for the same reason: we cannot tell whether the difference is due to smoking or to some one or more of many other factors such as differences between the groups in home surroundings, general intelligence, or to drinking or other habits.

In addition to isolating the facts to be observed and

controlling all other significant influences, the scientific method demands that an observation must be repeated before it is finally accepted. The possibility of repetition must be insured by a careful description of the experimental conditions. This is an important scientific safeguard. It is not sufficient that the same observer repeat an experiment, although this is desirable. He must state his procedure in full so that another investigator, perhaps one who is skeptical, may set up an identical outfit and repeat the experiment. In this way, errors in observation, recording, and computation, and mistakes due to failure to observe all of the influences at work or to other defects, are frequently discovered.

Isolation of the facts to be observed, control of other factors which may influence the results, and the provision for repetition of the whole procedure constitute the *experimental* method. An *experiment* thus differs from ordinary observation in that it is more carefully carried out, it is more rigid, cautious, and systematic.

The Use of Mechanical Aids to Supplement Observation.—Even with all of the precautions which characterize the experiment, the results may be incomplete and often erroneous since, even when well trained, observation is not infallible. Greater precision may often be obtained by the use of mechanical devices. The astronomer utilizing the telescope, and the botanist the microscope, are able to make more accurate and detailed observation than could be accomplished by the unaided eye. Especially useful for scientific purposes are the instruments which yield a permanent record of the facts which may be studied at any time by any person. Thus, both astronomers and botanists utilize extensively the photographic camera. Similarly, in psychology, instead of depending upon the report of an investigator who studies

the movements of the eyes by ordinary observation, we prefer the photographic records that may be secured by use of an ingenious invention. Instead of estimating the changes in distribution of the blood, the force of the heart beat or respiration during an emotion, it is better to secure graphic records by the use of a variety of delicate recording devices. Instead of describing the facial expressions verbally, it is better to photograph them. Advances in psychology, as in other sciences, have been occasioned, in part, by the development of instruments which have not only made observation more trustworthy but more detailed and refined.

The Need of Measurements.—Of prime value are those instruments which make provision for a quantitative statement—a measurement. One can estimate roughly the heights of men, but for scientific purposes they must be measured with standard instruments under standardized conditions. One can estimate roughly the relative speed of muscular reactions, but with a delicate timing device they may be measured in thousandths of a second. The brightest pages in the history of psychology are those relating to the development of measurements, and many inventions of measuring devices have made possible great progress in knowledge. The technique for measuring the frequency and duration of eye movements has been utilized in the study of a wide variety of problems in reading. The measurement of general mental ability mainly the work of the last decade has already led to researches that can scarcely be summarized in a single volume. The invention of measuring scales for educational achievement was the forerunner of much of the scientific work in that field. Human traits are most of them unusually difficult to measure because of their complexity and because of the variations in performance from

test to test. For some of the more complex human traits such as initiative, social sagacity, or persistence no very accurate measuring devices have as yet been developed and in proportion as these abilities cannot be measured, our knowledge of them remains inexact. Thus, in addition to isolation of the factors to be observed, in addition to control of all the significant influences, and in addition to the provision for repetition of the whole procedure by trained observers, the scientific method ideally supplants, or supplements, ordinary observation by objective records, given whenever possible in the form of a quantitative statement or measurement of the facts.

Statistical Methods.—In most investigations of human behavior, another difficulty is encountered: human subjects differ markedly from each other in their behavior and the same individual reacts differently at different times. Care must be exercised therefore that the results of an experiment are typical of the behavior of the particular subjects, and that the subjects adequately represent the whole class of people of which they are but samples. A single test of the speed of muscular contraction or a three-minute test of comprehension in reading is unlikely to yield a fair measure of an individual's ability. Perhaps it will require ten, twenty, or fifty tests of muscular contraction, or ten, twenty, or fifty minutes of time to secure a fair measure of ability to comprehend in reading. Even if it had been determined, furthermore, by very thorough testing that a small number of children who comprehended very well were also very slow readers, it would be unsafe to generalize that very slow readers have great depth of comprehension. If we found in a particular sixth grade that the brightest children were all rather nervous children, or that the boys of the group

surpassed the girls in memorizing poetry, statements about the general characteristics of bright pupils or of the sexes should not be hastily made. If we desire to solve general problems such as: what is the relation of speed and depth of reading; what is the relation of intelligence and emotional stability; or what are the relative abilities of boys and girls in general, we need more than a technique for handling individual experiments; we need *statistical methods.*

By means of statistical devices it is possible to ascertain how many times or for how long a time we must test an individual to secure a reliable measure of his reading or of any other ability. Similarly it is possible to determine how many individuals of a given age or sex must be tested to produce a measure fairly representative of the age or sex groups. In the event of an insufficient number of tests or individuals, it is possible to compute the magnitude of the error of the measures. This is but one of the statistical devices which form a part of the program for accuracy and precision characteristic of the scientific method.

Summary.—The scientific investigation should embrace the following characteristics: (1) The investigator should be properly trained; (2) he should isolate as effectively as possible the events to be observed; (3) he should control all other variables that might conceivably influence the results; (4) he should define the setting and procedure so that he or other investigators or both may be able to repeat the investigation; (5) when possible, he should employ objective measurements instead of ordinary observation and he should state his results in quantitative terms; and (6) he should take careful account of the extensity of the measurements, the number and characteristics of the subjects, by means of which

knowledge the statistical reliability of the results may be ascertained.

The Development of Hypotheses and Laws

The immediate aim of experimentation, guided by such rules as those just given, is to secure facts. An appearance is admitted to be a fact when several investigators, under identical conditions, observe it. The aim of science, however, is not merely the accumulation of particular facts; it is more than this, namely, the interpretation of facts, the discovery of principles, laws or general truths. When Benjamin Franklin flew his kite in a thunder-storm, he observed a phenomenon, an electric spark jumping from the cord. Verified on other occasions, it was recognized as a fact. When Franklin stated as a result of his observations that lightning was merely a huge electric spark, he had gone beyond the observable facts. He had developed an hypothesis which was borne out by later investigations and finally accepted as a general principle, a law or general truth.

An hypothesis is any conception by means of which the mind goes beyond the facts and seeks to establish relations between data that have been observed. It is a conjecture, a guess, a provisional explanation; it is an interpretation or enlargement of what is observed. The development of hypotheses is one of the important features of the scientific work. The ability to generalize or theorize has been the outstanding characteristic of most eminent men of science. Conjecturing, guessing, theorizing, is not confined to any one period of an investigation; it is usually incessantly active, preceding, accompanying, following, and guiding all experimentation.

Just as the development of checks and controls of

observation in science reveals the history of man's endeavor to secure reliable perception and testimony, so the gradual formulation of a series of rules to govern the development of hypotheses, portrays the discovery of many typical errors of thinking and reasoning and efforts to remedy them. As a result, the scientific method now embraces a number of rules; all of the rules of logic and in addition certain others that aim to secure precision in the construction of hypotheses. Of these, we shall discuss but one, the Law of Parsimony.

The Law of Parsimony.—The Law of Parsimony which in one form or another has been accepted by all sciences, states that of several rival hypotheses, we should accept the one which is the simplest and which explains the most. Science favors, for example, the adoption of one group of explanations for learning of all sorts, typewriting, dancing, singing, memorizing, reasoning, rather than one set of hypotheses for memory, another for acquiring muscular skills, another for developing appreciation, and so on. What explanations are simplest must be determined by each science for itself. In psychology, this aspect of the Law of Parsimony has been rather generally adopted in a form known as Lloyd Morgan's Canon, which is here quoted from his "Introduction to Comparative Psychology" (1894): "In no case may we interpret an action as the outcome of the exercise of a higher psychical faculty (mental process) if it can be interpreted as the outcome of the exercise of one which stands lower in the psychological scale."

To illustrate Lloyd Morgan's Canon, let us suppose that our dog, caught in the forbidden pantry, cowers and whines piteously. What are the possible explanations of such conduct? Since the dog has been carefully trained to keep away from the pantry, and is an intelligent and

well meaning animal, he is suffering pangs of conscience. One can discern remorse and penitence in his tones; he simply regrets the sinfulness of his ways. Another explanation might be this: when the master happens upon the dog, the animal consciously remembers—has in fact a vivid mental picture—of what happened when he was last surprised in the pantry. On the basis of this memory revival, it was easy to reason what would probably be shortly forthcoming, hence the cowering and whining. A third explanation would be: the dog has for good reasons cowered and whined when previously caught in the pantry. Now, being confronted by the man-pantry situation, he reacts by cowering and whining, a direct motor reaction unattended by "conscience," "reason," "conscious memory" or any other "higher" mental process. The psychologist would probably accept the last explanation (or one somewhat like it) because it is simplest in the sense of being lowest in the scale of psychological explanation.

Psychology more than most sciences must be rigid in applying the Law of Parsimony, because fanciful and mystical explanations are supplied with such readiness. The prevalence of beliefs in magic, clairvoyance, telepathy, mind reading, mystic inspirations, premonitions, intuitions, and mind cures is illustrative of the readiness with which the supernatural rather than the simplest of psychological explanations are accepted. A New England girl, Beulah Miller, found herself possessed of a mysterious ability to divine many of her mother's thoughts; for example, she could tell whether her mother was thinking about the clock, the carpet, or the window, about the number 6 or 10. The girl was entirely ignorant of the means by which she accomplished these feats. While thought transference, independent of the channels

of the ordinary senses, is suggested by such a performance, the psychologist must search for simpler explanations. In this case it was found after careful investigation that the girl, without knowing it herself, was getting her cues from slight eye, lip, or bodily movements of the mother who was not aware of having made them.

Stages in the Development of Laws and Principles.— General truths, laws, or principles are arrived at gradually. First, we have the guess or speculation. When you read original investigations, you will find reported a number of particular observed facts and usually an effort to explain the facts, to generalize from the facts. As additional facts are secured which harmonize with the preliminary guess, the term *hypothesis* becomes proper. When the hypothesis is further substantiated by investigations, it may be dignified by the term *theory,* and when very thoroughly verified and proved the theory becomes a *law* or *principle.* The Law of Gravitation, for example, was first a mere guess, then a fairly well-rounded hypothesis, then a theory, until finally it became a law inasmuch as it held good in all of the cases in which it was experimentally tested.

In psychology, but few final principles or "laws of nature" have as yet been worked out. What we have are great numbers of particular facts and many hypotheses or *working hypotheses* as they are commonly called. The working hypothesis is a generalization formulated to explain the facts at hand but recognized as a provisional or approximate explanation. It is a general statement designed to explain faithfully and simply a large body of facts, a formulation with which one proceeds to *work* but which one attempts to correct, improve, and refine as additional evidence is secured. It is a law or principle in the process of perfection.

The Use of Laws in Prediction.—Because of its general applicability, the law or principle provides the means of making predictions, foretelling consequences. The astronomer utilizing the laws concerning the movement of planets can predict the exact moment at which the sun will rise each day for many years in the future. The physician observing certain symptoms, pulse, temperature, and the locus of pain, by virtue of known principles predicts, with more or less accuracy, the course of a disease and arranges the treatment accordingly. The psychologist, utilizing the principles of mental growth, predicts, at least roughly, from the results of an examination made at age seven, the degree of mentality that a particular pupil will possess at fifteen, and as such predictions become more precise, the educational and vocational treatment of children may be more adequately selected and controlled to suit the ability and needs of the particular individual. In so far as we are able to predict the future from the present, we may be able to meet the future more adequately. Prediction is an ultimate aim of scientific endeavor.

Science, then, does not differ necessarily from everyday interests in the materials studied; any subject matter may be studied properly by scientific methods. It is not necessarily more or less practical in point of view. Scientific knowledge differs from ordinary knowledge chiefly in these respects: it is (1) more precise and definite; (2) more certain and valid; (3) better organized; and (4) more universal in application.

Some of the general features of scientific study have now been mentioned. These features are common to all sciences and in so far as psychology or any other study is scientific, it abides by the rules and regulations of the scientific game. What distinguishes one science from

another is primarily the subject matter studied. Psychology, then, is the application of the methods of science to the study of certain data. We shall next consider briefly the nature of the subject matter of psychology.

The Subject Matter of Psychology

The Study of Human Behavior.—Psychology seeks to discover the general laws which explain the behavior of human beings. It undertakes to determine the rôle of the sense organs, of the nervous system, the muscles, glands, and other bodily organs in everyday conduct. It attempts to describe and classify the several types of activity of which the normal individual is capable. It seeks to explain these activities in several ways. It endeavors to ascertain what bodily organs are engaged in walking, speaking, judging distance, in anger and fear, in satisfaction and discomfort, in reading and thinking. It undertakes to determine what forms of action appear without learning; activities, which, like the breathing, swallowing, and crying of the newly-born infant, are the results of inner growth rather than training. Psychology also attempts to determine the principles which govern the process of learning to speak, dance, or read; to control one's temper or appreciate music; to solve geometrical problems or to learn in any field whatsoever. It attempts to disclose the nature of differences among individuals in capacities to learn, in temperamental and moral traits, and in specialized abilities of many kinds. It attempts to account for the causes of such differences, the character of their interrelations and the significance of each in the work of the school, in vocations, or social life generally.

When the subject of the investigation is another person

whose activities are observed either directly or by the aid of recording or measuring devices, the method is commonly described as *objective*. The activities of the other person become the *object* of observation. What he does may be observed as objectively as the operations of a machine, the activities in a mixture of chemicals, or the opening of the petals of a flower moved from darkness to light. The human being may be studied in the same manner that other natural objects are studied by such sciences as physics, chemistry, or botany, and all of the devices and precautions which constitute the scientific method may be utilized. Many of the problems of human behavior may be solved by this objective method used in common with all other natural sciences. We can observe movements of the limbs, of the eyes, of the facial muscles; we can hear and record vocal expressions; we can secure graphic records of respiration and pulse and chemical activities from glandular secretion. With one exception, every kind of human activity of which we now have a conception may be objectively studied. The one exception is consciousness, that is, one's subjective mental experiences, one's sensations, images, memories, feelings, emotions, and impulses, and the study of these activities lies rather exclusively within the province of psychology.

The Study of Consciousness.—The description, classification, and explanation of conscious or mental activity is one of the most important, even if one of the most difficult tasks of psychology. To secure some idea of the kind of problem that psychology may attempt to solve, suppose you try an experiment, now classic, by means of which the eminent scientist Sir Francis Galton was the first to disclose some interesting facts about conscious states. Seat yourself comfortably and try to recall as vividly as you can the morning's breakfast table. Can

you see, in your mind's eye, the table, dishes, faces, food, and other details? Are these visual images dim or clear? Are they as bright as the actual scene? Can you really image the colors of the china, of the toast, eggs, coffee, etc., quite distinctly? Can you image the whole scene at once? For example, can you image all four walls of the room at once, or only the area that you could see from the particular position in the room? Where do the images seem to be situated? Within the head, within the eyeball, just in front of the eyes, or at a place corresponding to the real situation of the room? Can you retain the image steadily? With or without effort? Can you project it to the wall?

In these, and other studies of consciousness, the data of investigation are purely subjective experiences, observation of which is called *introspection* as distinguished from observation of the acts of another individual or of other events external to the observer. The investigator here as elsewhere should be properly trained, he should isolate the mental state to be examined and control other variables by excluding irrelevant factors, especially distractions, and by setting himself a particular task and holding to it; he should repeat the observation and apply statistical methods to the results. In two respects, introspective investigations fall short of the ideal scientific program: (1) the facts under observation cannot be readily objectified or measured and (2) they cannot be observed by other investigators. There is no way, for example, by which your mental image of the breakfast table can be photographed or otherwise reproduced, nor can it be exposed to the observation of others. If you report, as one person did, that an image of the factory whistle comes as if colored brown, whereas the sound of the church bell is blue, how is any one to discover whether this is a correct

observation or not? The introspectionist answers that if similar experiences are reported by different people independently or if the same observer, known to be well trained and trustworthy, has the experience repeatedly, it should be considered reliable evidence quite like other types of experimental proof. In Galton's experiment, for example, many trustworthy individuals repeatedly found that their imagery of the breakfast table was "brilliant, distinct, never blotchy," others found it "fairly clear, brightness at least from one half to two thirds of the original" while others found their imagery to be "zero—no visual memories—recollect but do not see the scene." These reports are at once of useful reliability and in rough quantitative terms. The investigator may arrange a "scale" in which the highest degree of vividness, as quoted, is connected with the lowest by a number of steps or units which are roughly equal.

Introspective study is admittedly difficult, and unusual care must be exercised in utilizing the results of its use. Despite its limitations, it is the only mode of approach to many important problems in psychology, and in the hands of experts it has been and will continue to be fruitfully employed.

The Field of Investigation and Subjects Utilized

General psychology embraces the principles and explanations which hold for human behavior in general. The principles are drawn from investigations in many more or less specialized fields in which the immediate purposes of study are very diverse. Thus there are studies by psychological methods in the fields of business, education, law, medicine, religion, social service, etc., with many subdivisions in, and much overlapping among these fields.

Each of these special fields borrows facts and principles from the others and applies them to its own problems. In turn, each contributes facts and principles to the body of the general science. In fact, the general science is a compact and systematized statement of principles based upon the studies in the separate fields.

The facts and principles of general psychology are not based entirely on the behavior of normal human adults. Indeed, some of the most important advances have resulted from the study of children, animals, and abnormal individuals; and to these fields of research some attention should be given.

The Study of Children.—Infants and children are studied not only to provide an understanding of their behavior, but also to make more intelligible the behavior of adults. Because less complex and less distorted by training than those of adults, the native or inherited tendencies of infants and children are especially worthy of study. The learning of children, because of its relative simplicity and because it may be observed from the beginning, has been a fruitful field of research. The introspective reports of children are not highly reliable, and the analysis of consciousness is therefore extremely difficult.

A profitable procedure in the study of children is the *genetic method* which consists in following from year to year the growth of vocalization and speech, emotional tendencies, the capacity to memorize, and other traits. Among the early genetic studies are a number of detailed biographies based on observations of significant acts, remarks, and interests of individuals from birth to various stages of childhood. More recently, a larger number of infants in maternity wards have been the subjects of daily observation by more carefully controlled methods.

Where the behavior of such infants could not be objectively measured by timing devices, graphic recording apparatus, etc., it was frequently recorded by motion pictures, thus providing ample opportunity for observation by any number of interested investigators.

Of the whole period from birth to maturity, the span from 6 to 14 years—that is, roughly, the period corresponding to the elementary school—probably has been most thoroughly studied, partly because a larger proportion of the total population is available for investigation at these ages and partly because the schools, more than most other institutions, are alive to the value of scientific studies of their problems. It is in this field that measurement of human traits by means of standardized tests and scales, and studies of learning in school and other functions, have made the greatest advances. It is here that studies of individual differences, the character of variations in abilities, and their correlations have been most extensively applied.

The Study of Animals.—In attempting to arrive at the general laws which govern human conduct, the study of animals, like the study of children, has been fruitful—and for much the same reason: the relative simplicity of their behavior. In dealing with animals there is another great advantage; their activities can be much more thoroughly controlled. Whether cats will catch mice, or whether birds can fly without practice or without observation of the performances of others, may be determined by completely isolating the animal until the time when these activities usually appear, whereupon the animal is confronted, for the first time, with a mouse or an opportunity to fly.

Under conditions similarly controlled, the learning of animals, because of its relative slowness and simplicity,

has been the subject of extensive investigations by which, probably more than by observations of humans, the principles of learning have been determined. In addition to studies of instinctive behavior and the learning process, the relation of the sense organs and the nervous system to behavior has been investigated by methods often more adequate than those applied to human subjects, for the reason that it is possible by means of operation to observe the loss or distortion in behavior which follows the removal of bodily organs in whole or part. Finally, the evolution of bodily organs from the simple to the complex may be followed in the animal species and correlated with the development of behavior. Since there is every reason to believe that human behavior, like human structure, is in many respects similar to that of animals even if much more complex, the study of the relation of structure and behavior in the latter has been of great utility in interpreting human conduct.

The consciousness of animals, of course, cannot be directly studied. At best, it may be indirectly inferred from their behavior; and such practice is too risky to yield information of much value in interpreting the human mind.

The Study of Abnormal Individuals.—Among animals, children, and adults, individuals who deviate widely from the average either by inherited deficiency or aptitude or by acquired defects or ability have been found worthy of study, not only for their own sake, but because they often disclose in sharp relief the presence or absence of a normal function. Just as a defective part of an automobile attracts our attention and leads to a closer understanding of its function, so among children who are normal except with respect to their incapacity to learn to read or spell we may often by the identification and study

of a particular defect secure a better understanding of the child and the function.

Studies of the blind or deaf, of those suffering less severe sensory defects, of patients whose brains have been partly destroyed by accident or disease, have contributed greatly to knowledge of the functions of these organs in normal life. In delinquent children, criminal adults, the insane, in the emotionally or nervously instable, common human functions are often found in exaggerated form and are consequently the more readily observed. The equipment of the extraordinary musician, mathematician, mechanic, or executive may display other traits in extreme form.

The Study of Groups.—To profit most fully from studies of the extremes, whether above or below the average, it is necessary to consider the intermediates as well. To this end many statistical methods have been devised by which the whole array of abilities, from one extreme to the other, may be considered at once. Of these, the technique of correlation is most familiar. It is a device by which the interrelations of two (or more) abilities in a group of individuals may be determined. Thus, by determining both the speed of memorizing and the length of retention of material by a group of subjects, we may ascertain whether, in general, rapid learning is associated with rapid forgetting, with slow forgetting, or with neither. By the same device it is possible to determine whether the rate of reading is, and to what degree it is, correlated with depth of comprehension, with general mental ability, or with any other ability that can be measured.

Doubtless the largest group study by means of scientific instruments under standardized procedure in the field of psychology was the measurement of the mental abili-

ties of more than one and a half million men in the American Army during the Great War. From these data, correlations of mental ability with height, weight, nationality, schooling, vocation, army achievements, and other abilities have been or may be computed. In this way, much is learned concerning the organization of human abilities and the factors, native or acquired, that influence them.

Psychology for Students of Education.—In a Psychology for students of education most of the laws and principles which constitute General Psychology will be utilized. Of the innumerable particular facts gathered in the several branches of the science, many of them—of use to the physician, the lawyer, the advertiser, the salesman, the musician, or other people—are of relatively little importance for the student of education. The following chapters will include those principles and many of the particular facts from psychology (and many borrowed from other sciences, as well) which seem to have the most important bearing on education. They will be presented in four main divisions: (1) a description of the form and function of the bodily organs and mechanisms upon which human behavior depends; (2) a discussion of man's equipment of unlearned (instinctive) activities and capacities; (3) the general laws of learning and their application to the teaching and learning of school and other functions; and (4) the important facts and principles of individual differences, their significance, correlations, and the devices by which they are measured.

The Reaction Hypothesis

Before undertaking any of these problems, a working hypothesis, quite fundamental to all of them, should be stated in abbreviated form to establish the general point

of view that will be elaborated and substantiated throughout the book. The hypothesis is this: all forms of human behavior, whether muscular activities, such as those of grasping, striking, or speaking; glandular activities, such as the secretion of tears, saliva, or gastric juice; or mental activities, such as perceiving, imaging, remembering, thinking, or reasoning, are reactions to definite stimulation. This may be called the *reaction hypothesis.*

If we prick lightly with a pin an earthworm, a rat, or a dog, an infant or an unsuspecting adult, we will invariably secure a sudden and pronounced reaction from the organism stimulated. The stimulus, here as in the following illustrations, is that force or action which produces a reaction. By a reaction is meant some effect or change produced by the release or transformation of energy. In the case of the start on the event of the pin prick, the reaction is due to the sudden release of energy stored in the muscles. The amount of energy released or transformed may be very much greater than the amount transmitted to the organism by the stimulus. A reaction, as the term is here used, means more than the mere transmission of energy from one object to another, as when a moving billiard ball striking another throws the latter into action. The human body on receiving a bump does not topple over like a dummy; it makes an immediate adjustment or reaction to the stimulus. A tiny prick, occasioned by a very slight amount of force, may cause a reaction in which a very large amount of energy is consumed, or, more accurately, transformed. The body contains large amounts of energy stored in various reacting mechanisms which, during the transformation of energy, are thrown into action as the result of appropriate stimulation.

To the statement that muscular activity is initiated by

some stimulus no one would object, because motor reactions have been so thoroughly studied and because their characteristics can be relatively easily observed. Everyday activities, as well as the experiments of the physiologist in his laboratory, afford samples. A pinch causes a jerk, a tickle causes a quiver or a sneeze, a sharp sound causes a turn of the head, and a strong light causes the narrowing of the pupil or a wink. In all these cases, the reaction is more extensive than these descriptions would indicate. If a strong light or a cinder strikes the eye, the muscles of the eyelid react, causing a wink; but careful observation would show other activities, such as the secretion of tears. The tears, like movements, are the results of a reaction; the reacting mechanism in this case being a gland—the lachrymal gland.

The physiologist has for a long time been acquainted with glandular mechanisms whose activities, or better, reactivities, are fairly well understood although not so well as muscular activities. While glands may differ greatly from muscles in structure and in the products which their activities yield, they seem to be very similar in the way their activities are controlled. Normally, there must somewhere be a stimulus which throws the mechanism into action, and investigations indicate that normal muscle and gland activities are alike in the sense that they are forms of reactivity.

When the human subject is stimulated by a pin prick, a bright color, or a sharp sound, characteristic muscular reactions and usually glandular reactions occur, but these are not all. He is *aware,* he is *conscious* of the pain, the color, or the sound. These subjective experiences are classified as mental activities, or states of consciousness. They are often popularly conceived as rather mysterious manifestations, as different from any other human ac-

tivities, as governed by quite different laws than muscular or glandular reactions. The facts seem to be, however, that all of our conscious experiences, our sensations, images, ideas, or emotions, are really reactions occasioned by definite stimuli, and that mental activity is quite as uniformly law-abiding as muscular or glandular activity. Sensations, thoughts, and feelings do not appear without causes; they are definitely determined, susceptible to analysis.

Most of the stimuli with which psychology is concerned are very complex; many forces, some from within and some from without, are acting on the organism at the same time. A complex group of stimuli is called a *situation.* If we are observing human reactions to a pin prick, to a patch of red or blue, to a sound of high or low pitch, or to an application of cold, *stimulus* would be the proper term. If we were examining human reactions to any combination of stimuli, such as the sight of the teacher, the sound of her voice—in general, to the events in the school room as a whole—we would use the term situation. A situation, then, is a combination or complex of particular stimuli. These terms mean the same thing, except that situation implies greater complexity.

The response is also very complex as a rule. When the teacher calls the name of a pupil in the classroom, careful examination would disclose a highly complex group of almost instantaneous reactions in the child's organism. There would be, of course, awareness or perception of the name and other mental responses as well as muscular reactions of straightening up, coming to attention and contraction of muscles in all parts of the body. Striking changes in breathing, in heart action, in many other internal organs—prominent among them the glands—would be disclosed by the application of proper

instruments. The whole reaction is complex, involving all types of responding organs in all parts of the body. What distinguishes one reaction from another is the pattern; many of the mechanisms, particular muscles or glands, are involved in a great many different total reactions.

Psychology undertakes to analyse the situations which the world affords and the reactions that human beings make to them. In addition, our task is to account for the one in terms of the other. Given a certain situation, how will the six-year-old child react to it? Observing the child's reaction, what was the probable cause of it? How may we kill off those reactions that are undesirable? How may we modify where only modification is needed? How may we strengthen the desirable reactions? What, in general, are the important facts concerning human reactions as we find them in the various situations of life? This is, broadly stated. the question which psychology attempts to answer.

QUESTIONS AND EXERCISES

1. What is the distinction between introspection and reasoning or philosophizing?

2. In what respects, if any, is introspection less scientific than the *objective* methods of study?

3. Which of the following experiments would necessarily be studied by introspective methods: (a) the determination of the most pleasing color combinations; (b) the determination of whether one can remember the *feel* of velvet; (c) the influence of alcohol on ability to add; (d) the content of a dream; (e) whether a very young infant or a dog ever dreams; (f) the facial expression in anger; (g) whether one's blood becomes heated in anger.

4. Out of brilliant red paper, cut a cross about 6 inches long with arms about two inches wide. Place the cross on a grey or white wall at a distance of about 10 feet. Gaze steadily at it for

about ten seconds. Then shift the eyes to a blank wall and gaze fixedly until the "after-image" appears. Carefully report the size, color, stability, etc., of the "after-image." Try with different shapes and colors. In this experiment, what method is mainly used? How would you make such observations scientifically valuable?

5. Try the same experiment with children of various ages. Compare their ability to see after-images with the ability of adults. Do you think children will make reliable observers of such facts? At what age do some of them succeed?

6. Why should psychology study animals, infants or insane adults when plenty of normal adults are usually available?

7. What, if any, are the distinctions between an hypothesis, a theory, a law, a principle? What is the difference between a scientific law and a civil law?

8. Of the following definitions of psychology, which were probably written by those mainly utilizing the introspective method; which by those mainly using the objective method of study; which by those who use both methods?

a. "The business of psychology is to furnish a systematic and coherent account of the flow of psychical process in its various forms, phases and stages, and of the conditions on which it depends." (G. F. Stout.)

b. "Psychology is that division of natural science which takes human activity and conduct as its subject matter." (J. B. Watson.)

c. "Psychology is the Science of Mental Life, both of its phenomena and of their conditions." (William James.)

d. "Psychology, in a word, is the science of the conscious and near-conscious activities of living individuals." (R. S. Woodworth.)

e. "Psychology . . . seeks to explain the facts of intellect, character and personal life." (E. L. Thorndike.)

9. List twelve important concrete problems with which you now expect psychology to be concerned.

COMPLETION EXERCISES FOR REVIEW

In the blank spaces in the following sentences, write words that will make a complete and correct statement. Such exercises are

called "completion tests." Check your responses by reference to the text.

1. Ordinary observation results in descriptions that are both ....and..........

2. In reports of observations of actual scenes as much as........ per cent of the statements are incorrect.

3. The unreliability of ordinary observation is due partly to ....in the particular field, partly to the..........of the events and partly to the..........of the events.

4. The investigator must be..........to..........in the particular field.

5. The investigator must..........the facts to be observed and ....all of the..........which may influence the results.

6. We can estimate causes and.........only when all......... have been..........or taken into account.

7. Provision for..........of an experiment is an essential feature of the..........method.

8. Whenever possible, the investigator supplements or.......... ordinary observation by the use of..........such as a.......... or a..........

9. Whenever possible, the results of an observation should be stated in..........terms, i.e. the facts should be..........

10. By means of statistical methods, the investigator should determine the..........of observations necessary as well as the ....of..........that should be observed.

11. Scientific knowledge differs from ordinary knowledge by being more.........and..........., more.........and........., better..........and more..........in..........

REFERENCES

For a more complete discussion of the general methods of science, of the pitfalls awaiting the ordinary observer, and some of the common fallacies in thinking, see R. W. SELLARS, *The Essentials of Logic,* 1917, especially pp. 173-239, or W. C. COOLEY, *The Principles of Science,* 1912.

For a more thorough discussion of the introspective method and a body of facts obtained by its use see E. B. TITCHENER, *A Textbook of Psychology,* 1919. For a psychology in which the objective method of study is used exclusively see J. B. WATSON,

Psychology from the Standpoint of a Behaviorist, 1919. Nearly all other recent books discuss and utilize both methods.

As introductory texts in some of the special fields, the following will be serviceable:

H. L. Hollingworth and A. T. Poffenberger, *Applied Psychology,* 1917.

M. F. Washburn, *The Animal Mind,* second edition, 1917.

J. B. Watson, *Behavior: An Introduction to Comparative Psychology,* 1914.

N. Norsworthy and M. T. Whitley, *The Psychology of Childhood,* 1918.

A. F. Bronner, *The Psychology of Special Abilities and Disabilities,* 1917.

Other books which utilize the reaction hypothesis essentially similar to that of the present text are, E. L. Thorndike, *Educational Psychology, Briefer Course,* 1917, and R. S. Woodworth, *Psychology,* 1921.

CHAPTER II

THE RECEIVING MECHANISMS

To understand the operation of any mechanical device, an electric motor or a steam engine, we find it profitable to take the device to pieces in order to study the form of the individual parts. The work of the whole machine is better understood when the contribution of each of its parts is known. So in the study of the behavior of man we shall find it profitable to dissect the organism in order to further our acquaintance with the component parts.

The mechanisms that we shall need to know may be considered conveniently in three groups: (1) *the receiving organs,* such as the eye and ear; (2) *the connecting organs,* the elements of the nervous system; and (3) *the reacting organs,* of which the most familiar example is the muscle. These organs are so arranged that the human mechanism is able to make many varieties of *reactions* to stimuli that originate within or without the body.

The Stimulus—Response Unit

First among these organs is the *receiving apparatus,* which may be called also the *receptor,* the *sense organ,* or the *sensory apparatus.* The receptor is highly sensitive to certain kinds of stimuli and when stimulated it initiates a nerve impulse. The sense organ always contains the end of a nerve which conducts the nerve impulse inward toward switching stations found in the spinal cord or brain stem. Here various connections with other nerves

are made until the impulse finally issues into muscles or other mechanisms where the reactions occur. The order of events then is: (1) the stimulus affects the sense organ, which (2) initiates a nerve impulse, which (3) is conducted through the nervous system, and (4) finally issues into the responding mechanisms. The whole system is usually thought of as a unit, a *reaction unit* or a

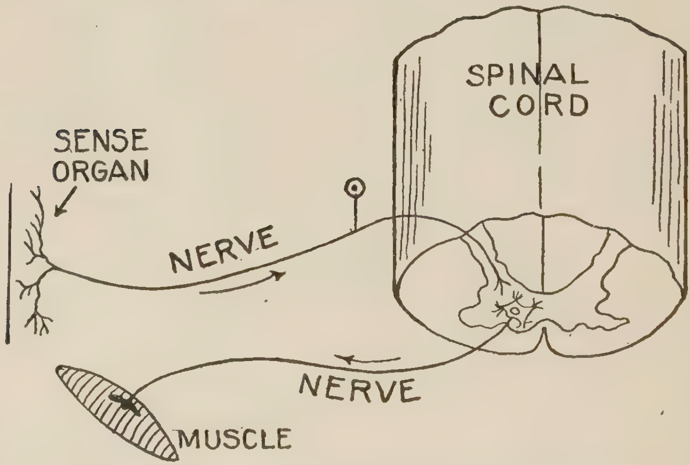


FIGURE 1. A simple reaction unit, or situation—response unit, consisting of the receiving mechanism (the sense organ) the connecting mechanism (the nerves) and the reaction mechanism (the muscle). The arrows show the direction of the nerve impulse.

stimulus-response unit. A very simple reaction unit including sense organ, connecting neurones and a muscle is shown in Figure 1.

Our everyday experiences lead us to think of the sense organ in connection with the sensations which go with it. When we think of the ear we think of sounds; the eye goes with colors; the nose with odors; the skin is thought of as the seat of cold, warmth or pressure. In many cases, we think of the sensation as being in the sense organ,

pain in the skin, taste in the mouth, odor in the nose. As a matter of fact, the mere effect of the stimulus on the sense organ does not produce the sensation. All that the stimulus does is to arouse a nerve impulse. The sensation, the sweet or the cold, is the result of a reaction set up in the brain by the nerve impulse. For the present we will be concerned only with the sense organs and the stimuli which influence them, leaving the sensations to a later chapter devoted to reactions.

Each receptor represents a high degree of specialization. Each is specially sensitive to one kind of stimulus. The receptors in the eye are highly sensitive to light waves but not to sound waves, to which the ear is attuned. Neither of these stimuli has an effect upon other sense organs under ordinary conditions. Certain intense stimuli such as a blow, electrical shock, or a strong chemical may arouse almost any sense organ, but this is an unusual event and such stimuli are termed *inadequate stimuli.* The *adequate stimulus* is the one to which a sense organ is specially adapted, the one which ordinarily affects it.

Sense Organs in the Skin, Muscles and Inner Organs

The receptors are so minute and numerous that no one has been able to make even an approximately complete inventory of them. The skin probably contains between 3,000,000 and 6,000,000 receptors. From 2,000,000 to 4,000,000 of these are called "pain spots," the simplest form of sense organs. They are responsive only to rather intense mechanical, chemical, or thermal forces, to severe pressure, blows, pricks, stings, heat, cold, acids, etc. There are probably at least half a million "touch spots" of many varieties in the skin. Some of these, lying close to the surface, are responsive to the slightest touch with a hair or

tuft or down; others, lying imbedded, are aroused only by rather heavy pressure, while many are scattered between the two extremes. Another variety of receptors, commonly called "cold spots" and numbering at least a half million, are aroused by heat radiations of a degree

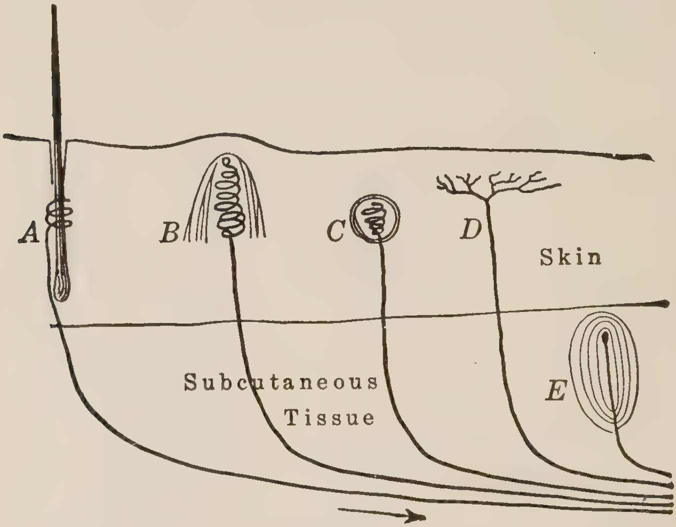


FIGURE 2. Diagram of several sensory end-organs found in the skin. *A* shows the sensitive nerve fibres coiled about the roots of a hair. Movement of the hair presses the fibres and thus stimulates them. *B* is a "touch corpuscle" consisting of a coil of nerve endings surrounded by other tissue. *C* is a bulb containing a fine coil of nerve endings. Probably sensitive to changes in temperature. *D* is a branched nerve ending of the pain sense. *E* shows a nerve ending surrounded by a layered capsule of a type found in the subcutaneous and deeper tissues. It probably belongs to the pressure sense. (From Woodworth's *Psychology*.)

lower than that of the skin. About 30,000 "warm spots" are responsive to temperature higher than that of the skin.

Sense organs in unknown numbers—millions of them, probably—similar to those of the skin, are found in the inner linings of the body, the nasal membranes, the gullet, stomach, and intestines, in the wall of the blood

vessels, in the ligaments and joint surfaces, in the fibres of the muscles, in the tissues of the lungs, diaphragm, glands, and other internal organs. The activities involved in muscular contraction and relaxation, the circulation of blood, breathing, digestion, glandular secretion, and other bodily activities, as well as the effect of chemical substances, bacteria, and internal temperature, may arouse some of these receptors. The importance of these receptors in daily life is very great. Each bodily process, such as breathing or moving the limbs, depends in part upon nerve impulses that are aroused by other bodily activities. One act, by stimulating the sensory mechanisms in the vicinity, becomes the stimulus to a second, the second to a third, and so on. Thus, in writing your name, the act of making one letter leads to the next in the series.

Sense Organs of Taste

The tongue contains in addition to organs sensitive to pressure, pain, warm and cold, other receptors, the "taste buds," so named because in appearance they resemble a rose bud, the stem of which is the nerve. The taste buds, whose sensitive endings project from the sides of little trenches in the surface of the tongue, are responsive to certain chemicals contained in liquids which may fill the trenches. The organs of taste are sensitive to four different classes of substances — sweet, sour, salty, and bitter. Many other substances do not stimulate any of these receptors and are, consequently, tasteless.

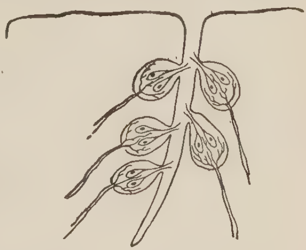


Figure 3. The taste buds are shown embedded in the walls of a crevice in the tongue. The nerve endings are entwined about the cells whose fibres project into the crevice.

Sense Organs of Smell

In the upper part of the nasal cavity, somewhat removed from the pathway of the air currents of ordinary breathing, is an area, about the size of a dime, which contains a large number of receptors that are sensitive to certain gaseous particles. As yet there is no reliable information concerning the number and kinds of substances which are adequate stimuli for the organs of smell. While

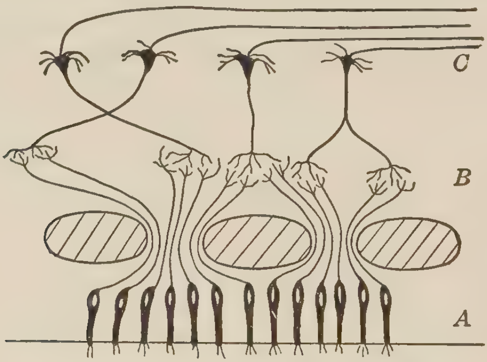


Figure 4. At *A* are shown the end organs of smell, the "olfactory cells," with tiny hairs projecting above the surface of the lining of the nasal cavity. At *B* the end organs connect with the nerves which run off (at *C*) toward the brain.

the number is probably large, there are doubtless many gases and air-floating substances that are not smelled.

The sense organs so far described are rather small in size and simple in structure comprising always the endings of a sensory nerve and, with few exceptions, some simple form of *accessory apparatus*. The accessory apparatus is not itself sensitive to the stimulus; it does not directly take part in initiating the nerve impulse, but serves to collect, modify or intensify the stimulus, and frequently, to protect the sensitive nerve endings from injury. The rôle of the accessory apparatus is most con-

spicuous in the case of the eye and ear, which are similar to the other sense organs except that they contain very elaborate accessory apparatus.

Sense Organs of Vision

The eye is round, except for a slight bulge in front. It is largely filled with a transparent jelly-like substance

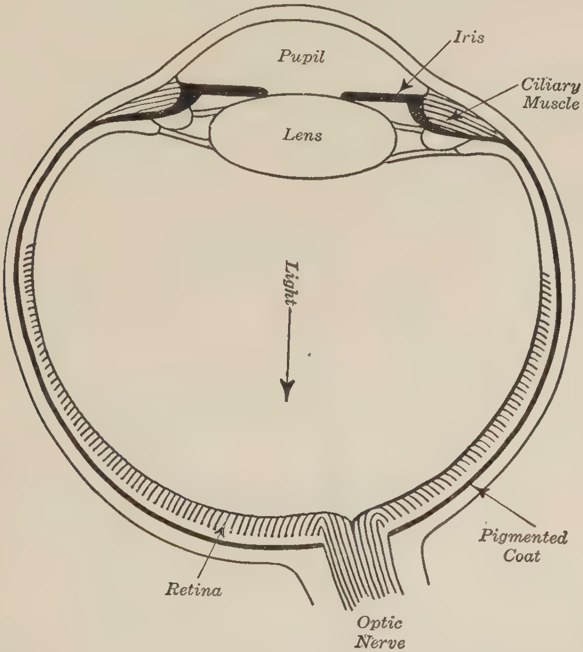


Figure 5. A horizontal cross section of the left eyeball. The sensory end-organs in the retina are very much smaller and more numerous than here represented. See text for description and Figure 6 for an enlarged diagram of the retina.

contained within three coatings, in the innermost of which are found the thousands of tiny sensitive nerve endings. Attached to the outer surface of the eye are

three pairs of muscles by which the organ may be directed toward the source of light. The bony projection of brow, the eyelid and lash, and the tear glands are part of the accessory equipment, and have, mainly, a protective function.

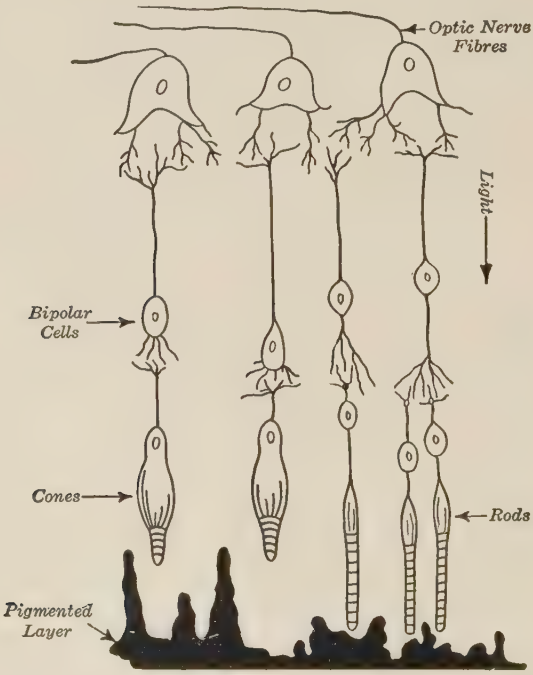


FIGURE 6. An enlarged diagram of the sensory cells and connected nerve cells in the retina. Light passes through the nearly transparent retina and is stopped by the pigmented layer beneath. Just above it are shown the "rods" and "cones" in which the nerve impulse is aroused and transmitted by the "bipolar cells" to the optic nerve fibres.

The adequate stimulus for vision is light; that is, wave-like movements of great rapidity conducted by a substance *ether*, which is assumed to fill all space. The light waves, originating in the sun or in some artificial source such as an electric or gas light, reach the eye di-

rectly or indirectly by reflection from objects in the environment.

The light waves from an object reach the surface of the eye and are admitted through a small opening which is surrounded by the *iris,* that small disc of blue, brown, or other color which is readily seen in the eye. The iris corresponds to the diaphragm of an ordinary photographic camera. When the light is strong, the photographer makes the aperture small; when the light is weak, he makes the opening large. In the eye, the *iris* automatically regulates the size of the aperture to suit the intensity of the light. Immediately behind the *iris* is the lens of the eye. Its function is the same as that of the lens of the camera, namely, to bring the rays of light to a focus—in the camera, on the sensitive plate or film; in the eye, on the sensitive *retina.* Focus is brought about in the eye by automatic changes in the shape of the lens. For distant objects the lens becomes relatively flat and thin; for near objects, round and thick. Light, reaching the retina, initiates nerve impulses which are carried to the central nervous system. Only the little end-organs in the retina are sensitive to light; everything else is accessory apparatus.

Sense Organs of Hearing

The adequate stimuli of hearing are wave-like disturbances set up by a vibrating medium such as a piano string or the vocal cords, and conducted by the air or by other substances—metals, liquids, bones, wood, etc. The waves consist of pulsations ranging in rate from about 16 to about 40,000 per second. There are waves above and below these limits, but to them the ear is not attuned.

Like the eye, much of the ear consists of accessory ap-

paratus, of which only the least important, the external ear shell, is visible. The external ear, together with the hollow tube leading into the skull, serves much the same function as the speaking tube of a recording phonograph or dictaphone; that is, it collects and directs the air waves

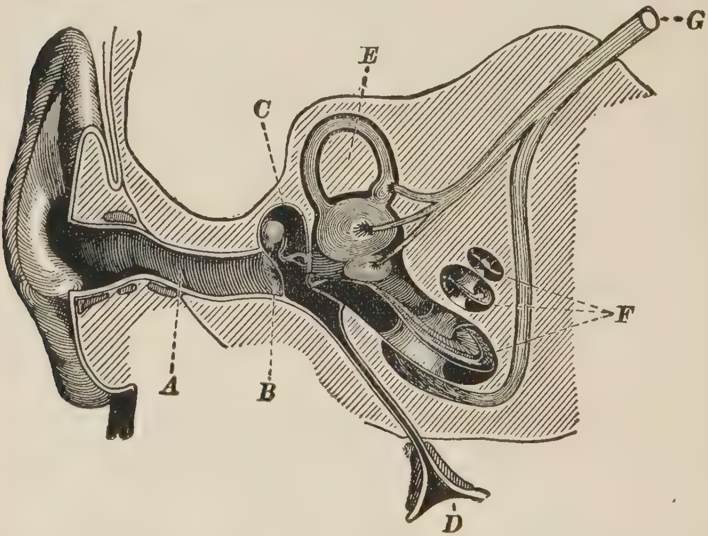


FIGURE 7. Diagram of the Ear. Collected by the external ear, the sound is carried down the canal *A* and strikes the vibrating membrane *B*. The vibrations of the membrane are transmitted to the chain of little bones *C* which transmits the disturbance by means of the stirrup-shaped bone to the liquid which fills the inner ear, including the Cochlea *F* in which the sensory nerve endings of sound are located. *E* represents the semi-circular canals which contain the sense organs of equilibrium. *G* is the trunk of the sensory nerve. *D* is the Eustachian tube which affords an air passage between the middle ear and the throat. (From Angell's *Psychology*.)

inward until they strike a stiff membrane which is stretched across the bottom of the tube. Just as the membrane in the recorder of the dictaphone takes up the vibrations and transmits them to small metal attachments at the end of which is the recording needle, so the ear membrane—the "ear drum"—transmits the pulsations

to a series of small bones, the last of which sets into vibration the liquid in a chamber of the inner ear. In this deeply imbedded inner chamber are found the sensitive auditory nerve endings which are aroused by the pulsations of the liquid in which they are immersed. Just what receptors are aroused depends upon the rate of the pulsations. Slow vibrations which correspond to sounds

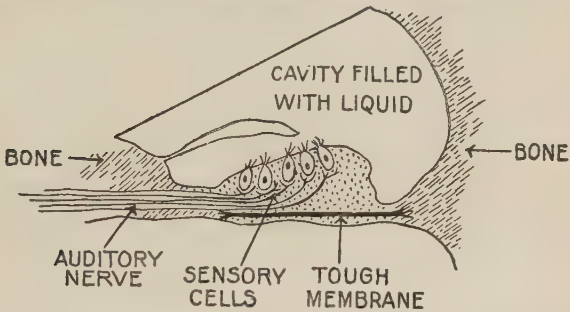


FIGURE 8. A rough sketch of the sensory cells in the inner ear. The cells are imbedded in tissues which rest upon a tough membrane. It is supposed that the membrane vibrates as a result of pulsations conducted by the liquid thus stimulating the cells. The auditory nerve is shown.

of low pitch affect some; rapid vibrations which correspond to sounds of high pitch affect others, according to one theory. According to another theory, a low pitch stimulates a very large number of the sensitive cells, whereas higher pitches stimulate a smaller number—the higher the pitch the smaller the number. There are other theories, no one of which has been universally accepted.

Sense Organs of Equilibrium

Adjoining the organs of hearing are three other mechanisms, the *semi-circular canals, the utricle,* and *the saccule,* which are responsive not to sounds but to move-

ments of the head. These organs consist of bony cavities filled with liquid, into which tiny sensitive hair cells project as reeds may project into a stream of water. Slight movements of the body disturb the liquids, whose changes of position are the immediate stimuli of hair-like sense organs. These receptors are involved in the acts of maintaining equilibrium when the body is moved in various ways, as by an elevator, a ship, or a street car, or when it moves by itself, as in walking, jumping, and stooping over. Any movement which involves the head, by its influence on these sense organs, activates nerve impulses that bring about appropriate bodily adjustments. The leaning inward by the child on the merry-go-round is a reaction mainly occasioned by the effect of the movement on these sense organs of the head. When they are injured, the maintenance of appropriate bodily positions under such circumstances is difficult or impossible.

In these brief descriptions of the sense organs, it will be apparent that the accessory apparatus—which in the case of the two most complex mechanisms, the eye and the ear, is similar to familiar instruments of human construction—serves merely to collect and modify the adequate stimulus. The really sensitive organs are very minute and, in appearance, fairly simple sensory cells. In them, the stimulus arouses the nerve impulse which is conducted into the central nervous system, there to be redirected to the organs of response. The stimulation of the sense organ is the first of the series of events which makes possible active adjustment to the environment.

While the number of different forces to which human receptors are sensitive is very large, there remain many to which no human sense organs are adjusted. There are

air waves we do not hear, light waves we do not see, particles and gases we do not smell, electric, magnetic, and other activities to which we are insensitive. Thus we are responsive to many but not all of the happenings of the universe. Whether a more extensive sensory equipment would make possible a more satisfactory adjustment to the conditions of life is an open question. But there is no doubt that the loss of a single type of sense organ from those we now possess results in a serious handicap in adjustment.

QUESTIONS AND EXERCISES

1. Is it true that there are but five sense organs?

2. What sense organs are stimulated by: (1) smoke from a hot furnace; (2) immersion in cold water; (3) a passing automobile; (4) a mustard plaster; (5) eating an onion; (6) doubling up the fist; (7) lifting a weight; (8) climbing a steep hill?

3. Compare the ear with a telephone.

4. Of what utility are the sense organs in the muscles and internal organs?

5. Mark the following statements *true* or *false*.

a. Some sense organs have no connections with nerves.

b. The stomach contains no sense organs.

c. There are at least four different kinds of sense organs in the skin.

d. The eye and ear contain the most elaborate accessory apparatus.

e. The reaction of one muscle is usually the stimulus to other reactions.

f. There are known forces to which no human sense organs are adjusted.

g. Sensations would be experienced in the sense organ even if the connections with the central nervous system were cut off.

h. The sensitive terminal of a nerve is an essential part of the sense organ.

i. Some sense organs include no accessory apparatus.

j. The eye contains but one sensitive terminal cell.

6. What is meant by an adequate stimulus? By an inadequate stimulus?

7. Is a force a stimulus if it does not arouse a sense organ?

8. What sense organs would, if destroyed, constitute the most serious loss to man? The least serious?

9. What, in general, is the function of the accessory apparatus?

10. How is it possible for man to discover the existence of air waves which he does not hear or light waves which he does not see? Have we any avenue of information other than our senses? Show how the discussion of the scientific method in Chapter I applies here.

REFERENCES

More detailed descriptions of the sense organs will be found in the following:

John Watson, *Psychology,* 1919.

R. S. Woodworth, *Psychology,* 1921.

G. T. Ladd and R. S. Woodworth, *Elements of Physiological Psychology,* 1911.

CHAPTER III

THE CONNECTING MECHANISMS

The Main Features of the Nervous System

A stimulus starts in the sense organ a nerve impulse which eventually occasions a response. Between the sense organs and the organs of response is a series of connecting links called neurones, which constitute the nervous system. First in order are the *sensory neurones,* distinguishable by the fact that they always originate in a sense organ and lead to the *central nervous system,* which is encased in the backbone and skull. From every receptor—from every tiny sense organ in the skin, in the muscles, internal organs, the eye, ear, tongue, etc.—run the delicate thread-like fibres of the sensory neurones which enter the central system.

The *central nervous system* comprises the *brain,* which occupies the large cavity in the skull; the *mid-brain* at the base of the skull; and the *spinal cord,* which fills a long slender hollow in the backbone. Most of the sensory neurones from the receptors in the head enter the central system at the base of the skull, the mid-brain level. The sensory neurones from the remainder of the body enter the spinal cord at levels which correspond to the levels of the sense organs in the body; that is, those neurones from the lower limbs enter at the lowest portions of the spinal cord, those from the upper limbs at the upper levels of the cord, and those from the trunk at intermediate levels.

The central system is essentially a switching station of tremendous complexity. It consists of millions of neurones which form inter-connections between the sensory and the *motor neurones.* The motor neurones are those which, issuing from the mid-brain and spinal

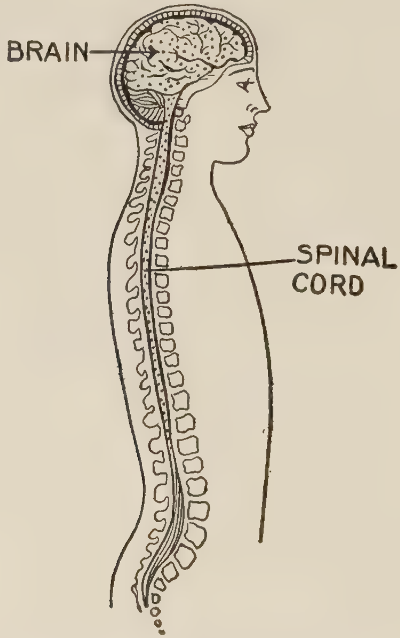


FIGURE 9. A general view of the brain and spinal cord. The mid-brain begins at the base of the skull but is mainly covered by the brain. The spinal cord as here represented is relatively too large; its actual diameter is about that of a pencil.

cord, run to the various organs of response, such as the muscles of the head, arms, trunk, limbs, feet, and internal organs. The neurones which carry the nerve impulses from the sensory to the motor neurones are called *central neurones* or *inter-connecting neurones.*

There are millions of neurones of each of the three

types—*sensory, central,* and *motor*—but the central neurones are by far the most numerous, so complex is the inter-connecting system. It is probably the most com-

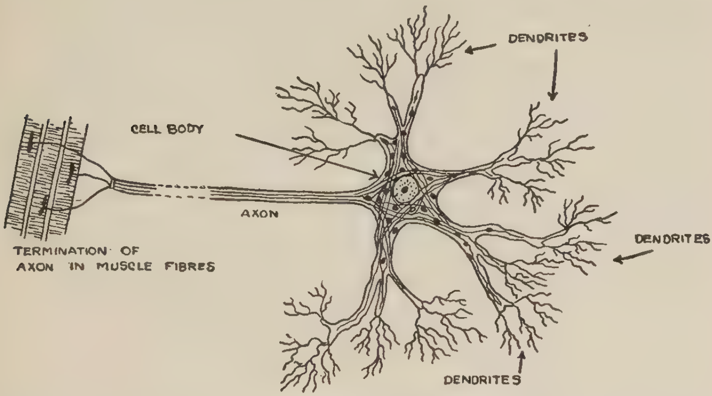


FIGURE 10. A motor neurone highly magnified. The axon is sometimes several feet long.

plex structure in nature. To count the neurones in the body, assuming a rate of two per second for eight hours a day, every day in the year, would require at least a thousand years.

Structure and Function of the Neurones

Although differing greatly in size, shape, and complexity, neurones are alike in certain important respects. They always include a *cell body* and a number of fibres. The cell body is a small but complex structure essential to the life and function of the neurone as a whole. The long, wire-like fibres which conduct the nerve impulses from one place to another are called *axons.* Thus, from a sense organ on the foot, an axon runs up through the leg and hip until it reaches the spinal cord just below

the waist line. Usually a number of axons from adjacent sense organs are grouped together to form a *nerve,* as telephone wires are collected to make a cable. All of the central neurones contain axons which run from one part of the central system to another, sometimes for very short, sometimes for long, distances. The axons of the motor neurones are the long processes which connect the organs of response with the central system.

The central neurones and the motor neurones contain a bushy group of relatively short fibrils called *dendrites,* whose function it is to pick up the nerve impulse from other neurones. The sensory neurone discharges its nerve impulse into the spinal cord by means of its axon, which is frayed out like the tasseled end of a cord on entering the central system. The dendrites of central neurones either come into contact or into close proximity with the endings of the sensory axon from which they receive the nerve impulse. The dendrites usually converge at the cell body out of which the axon leads to the dendrites of other neurones. In the case of the motor neurones, the dendrites lead to the cell body from which the axon conducts the nerve impulse to the organs of response. The dendrites, then, receive, whereas the axons carry on and discharge the impulses. The sensory neurones do not receive from other neurones and consequently have no dendrites. They consist of the end organs in the sensory apparatus, the long axon, and, of course, the cell body which is usually near the discharging end of the neurone.

The Synapse.—We must give special attention to the junction between two neurones, the place where the axon endings of one neurone reach the dendrites of another—a place called the *synapse.* The axon endings and the dendrites do not actually unite or fuse; they simply come

into contact or more or less close proximity. Each neurone is an independent unit, like two trees growing with branches close together or intertwined. Each tree is independent, touching but not joined to the other. The association of neurones at the synapse is of that character. The synapse, then, is not an organ or thing but merely a *place where* axons and dendrites come into contact or are close together.

The nerve impulse makes its way across the synapse

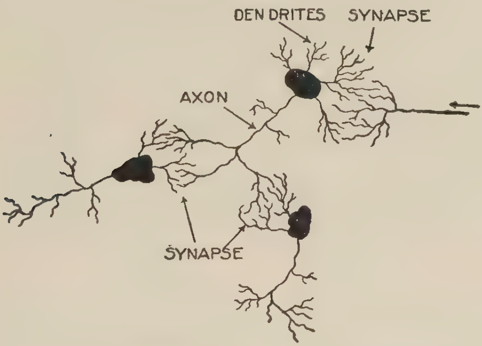


FIGURE 11. Three synapses or "synaptic connections" are shown.

when conditions are favorable, always from axon to dendrite, never in the opposite direction. Typically the endings of the axon make contacts with the dendrites of many different neurones; that is, there are many synapses, but usually the nerve impulse follows but one or a few of the possible pathways. At some synapses great resistance is offered to the passage of the impulse; at others, relatively little. The impulse crosses only those synapses where the resistance is low. Thus the degrees of resistance offered at the synapses (or synaptic connections) determine the course a particular nerve impulse will take and, in effect, what reactions will be made. What makes the resistance high at some synapses and

low at others is not known. It may be the spatial proximity of axon endings and dendrites, the inner composition of the fibrils, or some other condition.

The nerve impulses, because of conditions which must at present be described rather vaguely as differences in resistance at the synapses, do not become scattered and diffused throughout the whole central system and, as a consequence, throughout the whole bodily equipment of reacting mechanisms. On the contrary, they take particular, limited courses and evoke responses by certain organs only. There are predetermined routes from particular sense organs; routes determined by conditions at the synaptic connections. Some of these routes are short; some are round-about; some are inherited just as bones and eye-color are inherited; some are acquired through experience as wrinkles and table manners are acquired.

Levels of Organization of Connections

Routes and Reactions of the First Level.—The simplest stimulus-connection-response unit (which may be designated by the symbols *S-R*) consists of a sensory neurone, a central connection, a motor neurone, and a muscle. Stimulation of the sensory neurone results in a response by the muscle. Thus a slight prick of the skin on the finger or eyelid would cause a contraction of a local muscle. There is always a slight interval between stimulus and response, since some time—between 1/10 and 2/10 of a second—is required for the nerve impulse to get under way, to complete the route to and from the central system, and finally to arouse the muscle. Such a simple and relatively prompt S-R unit is often called a *reflex arc,* the reaction a *reflex act* or a *reaction of the first level.*

Usually the response is not so simple, but involves several organs of response. Each sensory neurone makes connections with many effectors by means of central neurones in the cord (or mid-brain); but of these one, two, or some other limited number of effectors, depending on the resistances encountered at the synapses, will be activated.

A great many reflexes or reactions of the first level may be observed in an infant very shortly after birth. A prick on the infant's foot elicits a quick jerk of the leg. Uncomfortable stimuli such as tickles, pricks, heat, or cold applied to other parts of the body provoke prompt avoiding reactions. An object striking the cornea causes

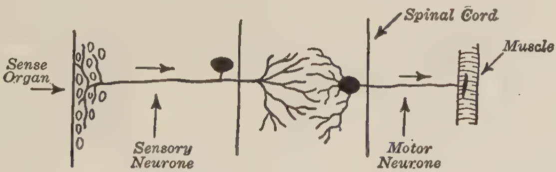


FIGURE 12. The mechanisms involved in a reflex act or a reaction of the first level. See text for explanation.

the wink reflex. Milk in the mouth causes a gush of saliva, a glandular reaction. Food on the back of the tongue causes a swallow; food in the stomach, gastric secretions and movements. A slight tickling of the nasal membrane causes a sneeze; an object on the palm of the hand, the grasping reflex.

All of these reactions are relatively simple, involving only the most direct routes (reflex or first level routes) through the central system, and activating a relatively small number of reacting mechanisms. The reactions are very prompt and certain, and for this reason they may be fairly safely predicted. They are uniformly found in normal infants, and since they can be modified or inhibited only with greatest difficulty, they persist

usually throughout life. For these reasons, tests of the first level reactions have become an important feature of the diagnosis of disorders of the nervous system.

Routes and Reactions of the Second Level.—In addition to traversing one or more of the innumerable pathways of the first level, a nerve impulse started, for example, by a pin prick on the foot, may make its way to routes of a higher level which are contained in various parts of the central system, located at the base of the skull, continuous with the spinal cord, and covered by the masses of the brain proper. Much of the mid-brain,[1] which is subdivided into many parts, and the *cerebellum* are devoted to connections of the second level.

We observed that a painful stimulation of the toe causes a jerk of the foot, the simplest reaction. Perhaps also movements of the hips, trunk, or arms occur—reactions which probably involve only connections or routes of the first level. In some cases, especially if the stimulus is a strong one, the subject may turn the head, readjust his equilibrium, gasp or shout, and show internal changes such as an increased respiration and heart beat. These reactions involve more complicated connections—connections of the second level—which are located in the mid-brain and adjoining portions of the central system at the base of the skull. These routes are shown diagramatically in Figure 13.

Reactions of the second level are said by many authorities to be instinctive or unlearned. Although there is some disagreement upon this point, it is certain that many of them are unlearned because they may be obtained in the newly born infant. If you hold the infant's

[1] Part of the mid-brain is utilized for first level connections by the organs of the head, so that it includes both first and second level connections.

nose, he first jerks slightly (first level) but later moves up his hands, pushes at the offending object, and later kicks, yells, squirms, and grows red with anger. Place the infant's face in the pillow, he will attempt to draw the head back (first level probably) and shortly kick, move his arm, squirm, and perhaps succeed in turning around. Such reactions as turning the head to sounds or

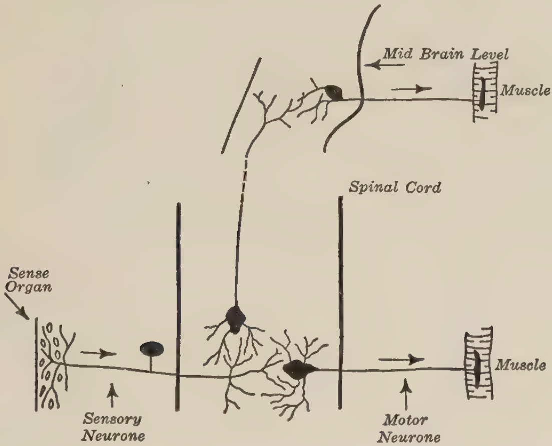


FIGURE 13. The connections involved in reactions of the second or mid-brain level. The neurone which runs to the mid-brain and another which connects with the muscle are added to the first level connections as shown in Figure 12.

moving arms up to things seen, or such complex reactions as the emotions of anger and fear, are usually second level reactions.

Reactions of the second level, as contrasted with those of the first level, as a rule take place in a part of the body somewhat more distant from the point of stimulation, and they are somewhat more complex, and somewhat less rigid, less invariable and more readily modified. These distinctions are not sharp, however, and only the expert

in neuro-anatomy is able to distinguish the levels involved in many reactions.

The mid-brain connections form complex pathways between different incoming and outgoing neurones, thus providing joint reactions to several stimuli received at once. Walking, stooping, running, jumping, and other complex bodily activities are responses made to many stimuli—from the organs of equilibrium in the skull, from the eyes, from the soles of the feet, muscular pressures in many parts of the body—which are pouring in at the same time. The mid-brain section provides for combination and redirection of these numerous impulses into motor nerves that provide coördinated and effective adjustment. Instead of many relatively independent and unrelated reactions, harmonious joint responses are thus secured.

Routes and Reactions of the Third or Brain Level.—The larger portion of the brain consists of the two cerebral hemispheres, or the cerebra, which we have hitherto spoken of as the brain proper, as contrasted with the cerebellum and mid-brain. By means of a chain of neurones, a nerve impulse originating at any sense organ may finally reach the surface or cortex (literally the bark) of the brain, which consists of a tremendously complicated network of neurones. The portion first reached by the incoming impulses is called the *sensory area*. From the sensory areas connections are made with the *motor area* where exist almost limitless possibilities of connections with other central neurones, by means of which effectors in any part of the body may be reached.

Reactions of the brain level may be of any degree of complexity, involving few or a great many effectors near to, or remote from, the point stimulated. We found the immediate withdrawal of the toe or foot, when it is

pricked, to be a reaction of the first level; the more general bodily readjustment, the turning of the head, the cry of pain, changes in respiration, etc., to be second or mid-brain level reactions. To apply camphor to the in-

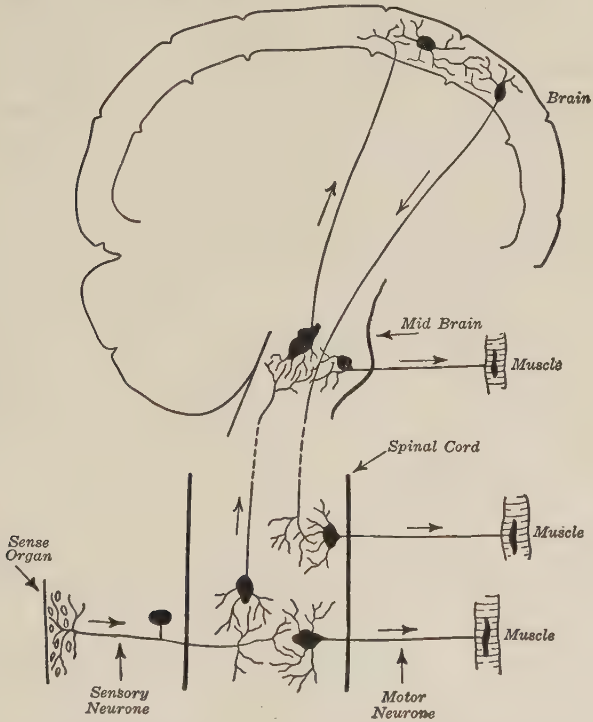


FIGURE 14. Connection of the first, second and third levels. The arrows indicate the several routes of the nerve impulse. See text for fuller explanations.

jured spot or to examine it deliberately would involve neural connections in the cortex. All learned reactions, so far as we know, depend upon connections established in the brain or cortical level. It has been fairly well demonstrated, for example, that the ability to speak or

write words, both of which reactions are clearly acquired, can be destroyed by removal or injury of certain portions of the cortex of the brain.

We have illustrated roughly the possible distribution of nerve impulses. Just what effectors will be aroused depends upon the conditions at the synapses. Certain synapses in the course of an impulse from any particular receptor, will be found to be "open," that is, to offer little resistance as a result of one's inherited organization. In this way, the unlearned or instinctive reactions, which involve mainly, and probably wholly, connections in the spinal cord and mid-brain, are accounted for. The relative openness of other synapses, particularly of those in the brain, is determined by the experience and learning of the individual. In fact, all learning consists in the modification of synaptic connections by the passage of nerve impulses across them. The exact nature of the nerve impulse, now supposed to be an electro-chemical process, is not known, nor is the character of the changes in the synapses brought about by the passage of impulses. A fundamental assumption of physiology, however, is that the transmission of nerve impulses does change the condition of the synapse in a way that makes subsequent passage more easy, certain and prompt. This change brought about by exercise is sometimes spoken of as lowering the resistance, causing greater openness or permeability of the synapse or in other ways, all of which imply the same general hypothesis.

The Operation of the Nervous System as a Whole

Diffusion of Nerve Impulses.—The nervous system is so organized that an impulse, initiated at any receptor, may make its way to many, perhaps to all, reactors. If

all switches (synapses) were open, any stimulus might produce all the responses of which the body is capable. An approximation to such diffuse reaction can be shown in a simple experiment. If we prick the foot of a frog with a stiff hair or a pin, the usual response is a slight jerk of the leg. A second stimulation of the same spot will provoke a bigger response of the leg; a third stimulus may bring the other leg into action, and further stimuli will show a spreading of response until the whole organism, probably every muscle and gland, is involved. The diffusion of response is secured more readily when a bit of strychnine, which lowers the resistance of synapses, is injected before the experiment is begun. Such diffusion of nerve impulse is, of course, not usually the case and never occurs except under extraordinary conditions, but it proves the general statement that from each and every receptor, pathways *may be* made through the nervous system to each and every organ of response.

The Convergence of Nerve Impulses.—The organization of the nervous system which has been sketched provides not only for the possibility of the passage of a nerve impulse from one receptor to almost all reactors, but for the convergence of impulses from many receptors upon one effector. That convergence, as well as diffusion, is provided for may be illustrated by an experiment upon a frog. A very gentle prod on the foot with a stiff hair may elicit no response, but when a slight sound is made simultaneously, the foot may jerk as it would for a more intense stimulation with the hair. If these two stimuli prove insufficient, a small flash of light added to the combination may cause the foot to jerk. The nerve impulses aroused in different parts of the body seem to have come together somehow and combined their energy on the muscle in the foot. A light, a sound, and a prick

on the foot are about as unrelated as any three stimuli could be, and if the impulses from these can be converged on the same effectors, it is probable that nerve impulses from any or all receptors may find their way to any par-

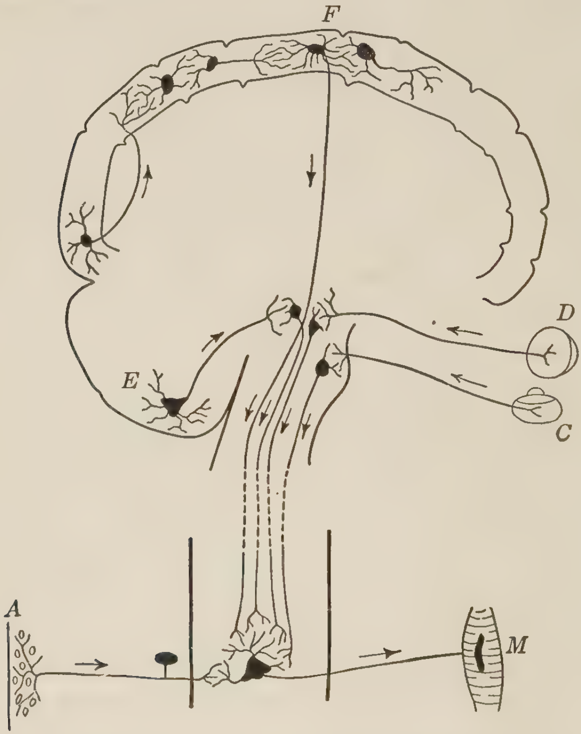


FIGURE 15. Connections of different levels by means of which muscle *M* may be activated. See text for explanation.

ticular effector. Indeed, this would follow as a necessary corollary of the fact of diffusion of impulses previously illustrated, i.e., the fact that from one receptor impulses may reach any given effector.

The mechanism of convergence is illustrated in Figure 15. Suppose muscle M to be in the foot. It may be

aroused by a stimulus, such as a pin prick which affects sense organ A in the vicinity of the muscle. The reaction would be a reflex. Impulses received from C, the ear, or D, the eye, by means of connections in the mid-brain level may also discharge into M. In everyday experience this occurs in many of our bodily adjustments brought about by things seen, heard, or smelled. When we are startled by sudden sounds, when we shift our equilibrium on observing an obstacle, or halt at a strong odor, the mid-brain level is involved. In most of our complex motor adjustments, connections in the cerebellum (illustrated by E) are also utilized. F represents a neurone originating in the motor cortex of the brain, and connected by motor neurones with the muscle M. Impulses from various parts of the brain (indicated by several neurones) may reach F and eventually discharge into the muscle M. Thus the response of M as part of any learned act, such as dancing, putting on a shoe, etc., is accounted for as well as what is usually called voluntary control—the arousal of M by an "act of will." Voluntary action is acquired action, not to be sharply distinguished from learned reactions in general. A particular muscle, then, may be activated by impulses which come from many sources directly through connections in the spinal level, from other sources through connections of the mid-brain level, and from still other sources through the cortical level.

Facilitation.—Since each muscle has fairly close connections with a number of sense organs, the stimulation of two connected receptors will produce a more prompt and vigorous response than the stimulation of one; three will be more effective than two; and so on. The energy from one impulse adds something to the effectiveness of the energy of others activated at the same time. This is

the phenomenon of *facilitation.* The neurologist is able to select at different points on the body the several sensory endings from which impulses lead rather directly to a particular effector; that is, he knows where to apply stimulation to secure relatively pronounced facilitation. The possibilities of facilitation are shown in Figure 15, and everyday life affords true, even if less precise, examples. If one is frightened while walking alone at night, one tends to speed up a little on slight stimuli; a crackle, the chirp of a night bird, or the sudden perception of a dark object may stir us to flight. The sight of food on the table, added to the odors and sounds from the kitchen, makes our hunger more acute. We shout at the horse, in addition to other stimulation, to get the greatest action. Thus, when two or more stimuli, each having a similar influence on a common effector, are given at once, each facilitates the others with the result that the response is more certain, prompt, and vigorous.

Inhibition.—Ordinarily a resting muscle is in a state of partial contraction or *tonus,* as it is called; and so far, we have considered only the influence of one or more stimuli in producing a greater contraction or a positive response. An equally important function of a stimulus is to arouse nerve impulses that depress the partial contraction, or *tonus,* or suppress it altogether. The application of certain chemicals, such as salt, to the cut surface of the spinal cord, will cause a relaxation of certain muscles which are then aroused to activity only by very strong stimulation, until the salt has been washed away. This is the phenomenon of *inhibition.* The usual jerk of the leg when an animal's toe is pinched may be depressed or inhibited by stimulating, at the same time, an appropriate spot on the other leg. A familiar sample of inhibition is the suppression of a sneeze by pressure on the upper

lip. Inhibition in the strict sense is more than mere blocking or prevention of a response; it involves a positive depression or reduction of the activity or tonus previously existing in the effector. There are different degrees of inhibition as there are of contraction, and the former is as much a reaction as the latter.

The nature of the nerve mechanisms upon which inhibition depends is not well known. In the case of the heart, at least, there are distinct sets of inhibitory neurones, but that all muscles and glands possess one set of neurones for stimulation and another for inhibition has not been demonstrated. Some authorities hold that the same neurones may conduct two kinds of impulses, one producing contraction, the other inhibition. However this may be, it is recognized that practically all effectors may be inhibited as well as stimulated. Combination of facilitations and inhibitions adds greatly to the flexibility of bodily reaction; it provides for a wider variety of adjustments.

Reciprocal Innervation.—Most bodily reactions involve both stimulation and inhibition so balanced as to yield the smoothest activity. For example, when the forearm is raised from the elbow one set of muscles, the biceps, contracts, whereas another set, the triceps, whose contraction would straighten out the arm, is inhibited and so is relaxed. If the biceps are stimulated artificially, by applying an electric current to their motor nerves, the triceps are innervated to inhibition. This phenomenon is called *reciprocal innervation.* Everywhere in the body muscles are arranged in antagonistic groups. Bending forward is antagonistic to bending backward; turning the head to the right to turning the head to the left; opening the hand to closing the hand; pulling to pushing; swallowing to spitting; and in the

case of heart, lungs, stomach and glands, increased activity is antagonistic to decreased activity. All complex movements, such as writing, dancing, boxing, involve reciprocal innervations in great complexity. When thrown into action, each muscle by means of its sensory neurones innervates other muscles, some to increased activity, others to diminished activity or complete inhibition. The result of such innervations is greater smoothness, coördination, and flexibility.

Summary

The nervous system is composed of millions of neurones which carry nerve impulses from receptors located in all parts of the body to the central system, which comprises the brain, mid-brain and spinal cord. The function of the central system is to switch the nerve impulses into certain motor neurones, running to reactors which are stimulated into greater activity, or depressed into less or no activity according to the character of the nerve impulse (or possibly of the nerve fibres). Each receptor may send a nerve impulse to many, perhaps to all reactors, and each reactor may be stimulated or inhibited by many, perhaps by all receptors. What course the impulse will take depends upon the resistance offered by the synapses. The various pathways may be grouped in three levels: (1) a first or reflex level involving connections mainly in the spinal cord; (2) a second level providing more complex connections in the mid-brain; and (3) a third level through the brain which is the seat, primarily, of acquired connections. Reactions through the lower levels are more prompt, certain and fixed. The connections are probably all native. Reactions involving the third level, the brain, are typically learned or ac-

quired, and are usually less prompt, less invariable from person to person, less certain and easier to modify.

QUESTIONS AND EXERCISES

A. Mark the following statements *true* or *false*.

1. There are but two groups of neurones—sensory and motor.
2. Some of the sensory neurones are contained wholly within the spinal cord.
3. The simplest reflex arc includes synapses within the central nervous system.
4. The dendrite is the discharging end of the neurone.
5. All neurones contain dendrites.
6. Axons are usually longer than dendrites.
7. Certain neurones in the brain have no cell bodies.
8. The mid-brain is the principal seat of acquired connections.
9. From each sense organ there is a possible connection with each and every organ of response.
10. The central nervous system provides innumerable possibilities for the distribution of nerve impulse.
11. Each muscle may be aroused by only one sense organ.
12. If the cerebral hemispheres of an animal were removed without other injuries, the animal would be totally incapable of movement.
13. Every sense organ is connected with the central nervous system.

B. Fill in the blanks to complete the sentences properly.

1. The receiving portion of the neurone is the ....
2. The degree of..........offered to a nerve..........by a synapse may be caused either by..........or by..........
3. Reactions of the first level are, on the whole, more.........., more.........., more..........and more.........than reactions of the higher levels.
4. Typical reflexes are.........., ..., ...
5. The central nervous system provides not only for wide ....of impulses but also for..........of impulses on a particular..........mechanism.

6. When two or more......... ...., having similar........ upon the same..........of..........are aroused at once, each will..........the other.

7. There are..........as well as..........impulses.

8. Playing the piano would certainly involve routes through the ....level because...... ....

C. Questions and Exercises

1. What does the symbol S refer to? The symbol →? The symbol R?

2. If the body were not organized for reciprocal innervation what kinds of difficulties might be encountered? Illustrate.

3. Give concrete illustrations of reflex acts. Of learned acts.

4. Draw diagrams of the three levels of connections.

5. Which of the following are reflexes: jerking the hand from a hot stove, throwing water on a fire, picking up a pin, running from a large beast, sneezing, spitting out a bitter substance, laughing at a joke?

6. Define the following terms: cell body, axon, synapse, dendrite, nerve, central nervous system, resistance, reflex arc, diffusion, convergence, facilitation, inhibition, reciprocal innervation, connection.

REFERENCES

E. L. Thorndike, *Elements of Psychology,* 1906, contains excellent illustrations of the nervous system. C. J. Herrick, in *An Introduction to Neurology,* second edition, 1918; G. T. Ladd and R. S. Woodworth, in *Elements of Physiological Psychology,* 1911; and Knight Dunlap, in *An Outline of Psychobiology,* second edition, 1920, give more detailed treatment.

CHAPTER IV

THE REACTING MECHANISMS

In Chapter III, the muscle was used as typical of the reacting mechanisms. So far as the principles of the reaction hypothesis—the assumption that all behavior may be accounted for in terms of reactions to stimuli—is concerned, muscular activity provides the clearest illustration. But we have emotions, feelings, sensations, memories, ideas, and other complex experiences that must now be accounted for. These will be better understood after a survey of the mechanisms of response, which will be considered in the following order:

I. Muscles whose reactions produce movements
   1. Striped or striated muscles
   2. Smooth muscles

II. Glands, whose reactions produce chemical secretions.
   1. Duct glands, such as the salivary gland
   2. Ductless glands, such as the adrenal gland

III. Cortical neurones whose activity is essential to states of consciousness, such as sensations and images.

Muscles

Striped Muscles.—The *striped* or *skeletal muscles* constitute a large part of our body. They vary tremendously in size, from large ones on the shoulders or in the legs to very small ones attached to the eyes or the

vocal organs. Each muscle consists of a large number of thread-like cells, the *muscle fibres,* which lie parallel to each other. Each fibre is supplied with the discharging end of a motor neurone. It is here that the nerve impulse, coming from the spinal cord, starts the contraction or relaxation (inhibition).

The vigor of a muscular reaction depends partly upon the strength of the stimulus. A strong pin prick, electric shock, or sound will cause a more pronounced reaction than a less intense stimulus of the same type. The single or "simple" muscle contractions vary in speed from muscle to muscle and from person to person. Measured by a simple test such as tapping with a pencil, voluntary contractions may vary from four or five to eight or nine per second over a period of fifteen seconds or more. A rate less than four per second is abnormally slow and sometimes is symptomatic of disease.

When one holds a pen, stands or sits in one position, holds the arms in place as in typing, keeps the eyes on a book as in reading, many muscles are persistently in contraction while others are persistently in inhibition. The continuous contraction or inhibition is produced by a series of intermittent nerve impulses, twenty or more per second, whose rapidity is too great to permit a return to the state of tonus between stimuli. The slowing of the rate of discharge in old age causes the familiar shaking which occurs when an object is held.

Smooth Muscles.—The *smooth muscles* are found chiefly in the visceral organs; in the walls of the gullet, the stomach, the small and large intestines, in the genital and urinary organs, the bronchi and diaphragm, in the walls of veins and arteries, attached to hairs, and in various glands. In structure the smooth muscles differ considerably from the striped: instead of threads the

elements are tapering spindles which unite to form a tissue, such as the wall of the stomach.

The smooth muscle spindles contain the endings of neurones that are somewhat different from those which supply the striped muscles. We need not be concerned with the minute differences, and need only note that certain motor neurones from the spinal cord lead to "ganglia" (i.e., groups of neural connections outside of the spinal cord) where they are connected by means of synapses with other neurones which run on to the smooth muscles. The neurones connecting the ganglia and the smooth muscles form part of what is called the *autonomic nervous system.* In Figure 16 is illustrated the extra *autonomic* link between the motor nerve and the muscle. Instead of one neurone running from the cord to the muscle there are two or more linked by synapses. Both serve the same general purpose, namely, to conduct the nerve impulse to the organs of response.

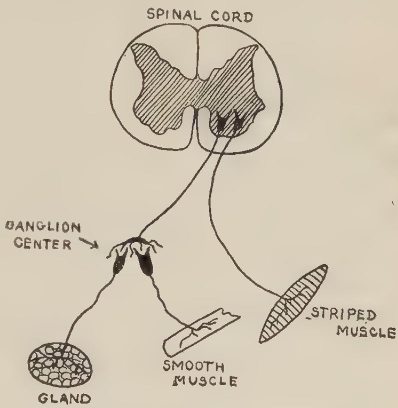


FIGURE 16. On the right is shown the motor neurone running directly to the striped muscle; on the left a motor neurone terminating in a ganglion center from which neurones of the *autonomic system* continue to the gland and the smooth muscle.

The activity of the smooth muscles is like that of the striated muscles except that it is slower. Smooth muscles are sluggish in reaching the maximum of a contraction and slow in relaxing. They will maintain different degrees of tonus for very long periods of time. Most

smooth muscles are very susceptible to the stimulating or inhibiting effect of certain chemicals, many varieties of which, developed in the body by glands, reach the "ganglia" as well as the muscle through the circulating blood. The paralysis of the iris of the eye (a smooth muscle) caused by applying atropin to the surface or injecting it into the circulation is probably the most familiar example of such effects.

The Glands

Until recently, study of the glandular mechanisms has been pursued almost solely by those interested in the digestion and assimilation of food, in storage and growth, and in the elimination of waste materials. Recent research, although not as yet extensive, has shown that glandular functions play an important rôle in behavior. Especially important is their relation to emotions, such as fear, anger, and joy; to temperamental and volitional traits, such as energy, vivaciousness, and ambitiousness, and even in the field of thinking and reasoning their influence is probably considerable.

The most familiar *duct glands* are the tear glands, the sweat and oil glands of the skin, the salivary glands in the mouth, the digestive glands of the stomach, the intestinal canals, the liver and kidneys. Each of these, by means of a duct or tube, pours its secretion on the surface of the body or into some body cavity. So far as is known, all of the duct glands are innervated by neurones of the autonomic system as are the smooth muscles.

The *ductless glands* are sometimes called the *endocrine glands* or the *glands of internal secretion*. They differ from the duct glands in that they have no external outlet. They produce complex chemical compounds which are absorbed by the blood filtering through them and

thus are carried throughout the body. The endocrine glands, like smooth muscles and duct glands, are innervated by the autonomic system. We can give but a brief and fragmentary description of a few of the internal glands and their influences on behavior.

The Thyroid Gland.—The thyroid gland consists of two maroon colored masses connected by a strip of tissue on each side of the windpipe, close to the larynx. Everyone knows the position of this gland because of its great enlargement in the disease, goitre. The most important secretion of the thyroid is *thyroxin,* of which the most potent element is arsenic.

When the thyroid becomes over-active, or when thyroxin is injected into the circulation or taken into the stomach, the effects, while slow in appearing, are very pronounced. The organism speeds up, is excitable and over-reacts. The pulse becomes rapid, the temperature goes above normal, and the skin is flushed and moist from perspiration. The individual is alert, irritable, unable to relax or sleep perfectly. Emotions, as fear, anger, excitable joy, are easily aroused. If the over-supply of thyroxin is continued, the individual loses weight no matter how much he eats; certain vital chemical activities (metabolism) go on at such a pace that they exhaust the reserve stores of the body.

All of these effects are symptoms of the disease, *exophthalmic goitre,* which is associated with hyper-thyroidism, that is, too much thyroid. Another disease, *myxoedema,* is a chronic condition of hypo-thyroidism, that is, insufficient thyroid secretion. In this disorder, the symptoms are quite the reverse. All of the vital activities slow up; bodily movements are slow and clumsy; the temperament becomes sluggish, indifferent, insensitive, dull.

The Parathyroid Glands.—The parathyroids are four in number, about the size and shape of grains of wheat, located two on each side of the windpipe and imbedded in the thyroids. The secretion of these glands has not been isolated and its specific effect is not very well known. When they are removed in experiments upon animals, the subject becomes extraordinarily excitable. At the slightest sound or touch it will jump or even be thrown into convulsions. Certain human beings suffering from extreme depression, nervousness, restlessness, insomnia, and tremors, have been found to have defective or diseased parathyroids. At the present time it is believed that these glands have an important rôle in the regulation of the assimilation of lime, which in addition to being an essential element of the bones, teeth, and blood, is required for the health of nerves. Removal, disease, or insufficiency of the parathyroids, by eliminating or decreasing the intake of lime, and perhaps in other ways, produces marked disturbances of behavior.

The Pituitary Gland.—The pituitary gland, a small organ about the size of a pea, is situated in a well protected position at the base of the brain. It is really a double organ giving two secretions, each bringing about a variety of effects. Over-activity of one of the pituitary secretions causes an abnormal growth of the skeleton. The giants which we see at the circus are probable victims of an over-active pituitary function. Insufficient secretion of one or both parts of the pituitary is said to be the cause of retardation of bodily growth in the case of certain types of dwarfs.

The pituitary secretions influence the tone of smooth muscles and the activity of various functions concerned in the transformation of materials into form available for bodily work. For example, the glycogen in the liver is

more rapidly converted into blood sugar—the material burned in muscular action—when the pituitary is active. The pituitary functions appear to be influential in determining fatigability; inability to sustain effort being one of the frequent complaints of those whose pituitary secretions are insufficient.

The Adrenal Glands.—Since the rôle of the adrenal glands will be rather fully described in the chapter on emotions, it will not be given here. Descriptions of other glands will be found in references given at the end of the chapter.

The Glands in General.—Our knowledge of the functions of the glandular mechanisms is as yet very inadequate. They form a complex system. A change in the amount of secretion of one affects many or all of the others. The details of the inter-relations have not been ascertained, but the system of reciprocal innervations involving both facilitation and inhibition, which we observed in the case of muscles, seems to have a parallel here. The secretions of the adrenal and the thyroid have certain common functions, as well as some different, almost antagonistic ones. The influence of adrenal secretion on the liver's control of sugar is quite the reverse of the influence of secretions from the pancreas. The whole complex of chemical reactions doubtless provides for many subtle adjustments, whose influences on human behavior we are just beginning to appreciate.

The Cerebral Cortex and its Functions

A description of muscular and glandular activities does not exhaust the forms of behavior that constitute our everyday experience. Most of us would rate high, in terms of importance, our sensations, thoughts and feel-

ings, that is, our conscious or mental experiences. There are two problems before us in seeking an understanding of mental activity: (1) upon what bodily organs do our states of consciousness, sensations, images, memories, etc., depend, and (2) what are the characteristics, varieties and functions of these mental states?

The Physical Basis of Consciousness.—We must admit at the outset that if we stand by scientific proof, we cannot say with certainty that the activity of any organ produces a sensation or some other state of consciousness in the same manner that a muscle produces a movement or a gland produces a secretion. All that we can say is that the activity of certain organs seems to be a necessary condition of conscious experience. These organs are certain neurones located mainly or wholly in the cortex or outer layer of the brain. The assumption is that the nerve impulse, initiated at the sense organ, is relayed through the cord and the mid-brain by axons leading to the sensory area in the cortex of the brain. When these cortical neurones are thrown into action by the nerve impulse, we have the condition under which consciousness occurs. The cortex seems to be the immediate physical basis, or, if you wish, the organ of consciousness.

Several lines of evidence favor the hypothesis that activity of the neurones in the cortex of the brain is the basis of conscious experience. The fact that a blow on the head or the stoppage of the flow of blood to the brain results in loss of consciousness is suggestive but not conclusive evidence. More convincing proof has been secured by observation of the effects of *partial* loss or destruction of the cortex by injuries, operations or disease. The removal of certain areas of the cortex invariably results in the loss of certain kinds of consciousness. The removal

of one area results in the loss of visual sensations—the individual is unable to see even when the eye and the sensory nerves are unimpaired. When another area is removed, the individual is unable to become aware of (conscious of) sounds although the ear and the sensory neurones are uninjured. The destruction of other areas abolishes sensations of pain, cold, hot, pressure, taste or smell. Widespread cortical removal results in losses of images, memories and other conscious experiences even though all other bodily organs—the sense organs, the cord and mid-brain, motor nerves, muscles and glands—are left intact.

Science is unable to explain the relation between activity of the cortex and consciousness. The immediate stimulus is the nerve impulse. When it traverses certain cortical neurones, a sensation or some other conscious state occurs, but just how or why is quite unknown. The circumstances, to use a rough analogy, are similar to those attending the production of light in an electric bulb. The electric current flows along the wire with no observable effect but, when it reaches the filament of the light bulb, there results a brilliant glare. No one knows, as a matter of fact, what electricity is nor precisely why it should, when circulating through the filament, produce light, rather than a sound, an odor or some other result. Of course, a certain number of facts are known concerning the properties and effects of the electric current, which provides an approximation to the explanation of the occurrence of light, but the explanation is not complete or ultimate. Less is known concerning the properties of nerve impulses and their effects on the neurones of the cortex, but the evidence nevertheless is such, that we must assume that nerve impulses flowing through certain neurones are the necessary conditions of consciousness even if

a complete or ultimate explanation of how or why is not available.

Localization of Conscious Functions

To some extent, the particular areas of the brain whose neurones are most intimately concerned with definite conscious states are known, and study of them assists somewhat in classifying and understanding conscious behavior.

Main Features of the Cortex.—The brain comprises the *cerebral hemispheres,* or the two *cerebra* (the singular term is *cerebrum*). The cerebra include the whole content of the skull except the mid-brain with its appendages. The dividing line between the cerebra is a deep central cleft. In general size and appearance, the cerebra differ from man to man about as faces do; the main features can easily be made out but minor differences are always found. Figure 17 gives pictures of the surface. The neurologists have the brain surface very carefully divided up, like a map, into various areas, using many of the depressions as boundary lines. There are four large areas: the Frontal Lobe in the forehead, the Temporal Lobe at each temple, the Occipital Lobe at the back and the Parietal Lobe on top; and two fissures, the Central Fissure which divides the front from the hind part, and the Fissure of Sylvius which begins at the temple and, running toward the rear, marks off the Temporal Lobe.

The nerve impulses initiated in the sense organs in various parts of the body are relayed by central neurones until they arrive at what may be called the *primary sensory areas* in the cortex. The primary sensory areas connected with the important sense organs are fairly definitely known. The impulses coming in from the eye are relayed to the portion of the cortex in the posterior part

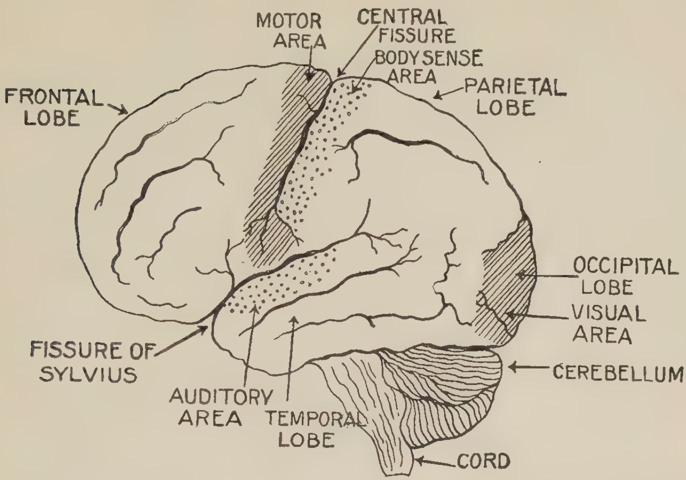


Figure 17. Side view of the left hemisphere of the brain showing the important fissures and lobes and the primary visual, auditory and body sense areas.

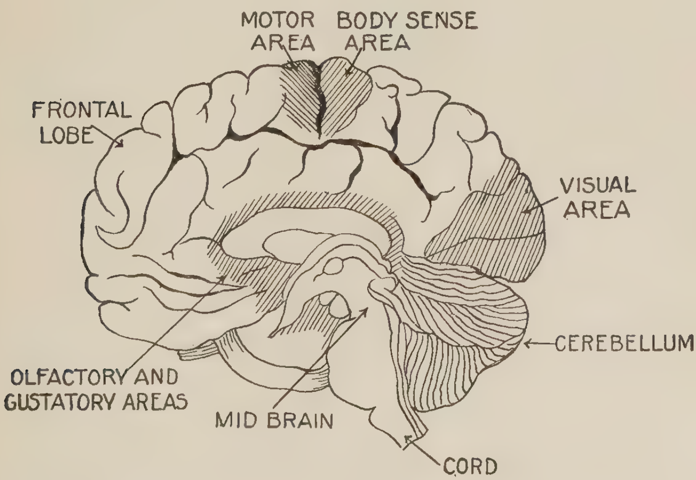


Figure 18. The inner (mesial) surface of the right hemisphere showing parts concealed in Figure 17. The olfactory and gustatory areas are also shown.

of the brain, i.e., in the Occipital Lobe. This area may be called the *primary visual area.* No other part of the cortex receives nerve impulses directly from the visual receptors. The impulses from the ear are conducted by chains of neurones to the area of the cortex in the Temporal Lobe. This may be called the *primary auditory area.* The organs of taste are connected with the *primary gustatory or taste area* which is near the bottom of the cleft between the two cerebra. In the same region is the *primary olfactory area* which receives the impulses from the sense organs of smell. The sense organs of the skin and, to some extent, those of the muscles, ligaments and joints, send impulses which reach the cortex in a narrow area which runs from the top of the brain down the posterior side of the Central Fissure, ending at the Fissure of Sylvius. This strip may be called the *primary bodily-sense area.* The primary cortical areas of other sense organs—such as those of the semi-circular canal and of many internal organs—are not known.

There are two important facts which we should know concerning the several primary sensory areas: first, they contain the neurones whose activity is primarily and essentially correlated with the conscious response, the *sensation;* and second, they are profusely connected, by neurones both in and under the cortex, with many other parts of the brain.

The Effects of Removal of Parts of the Cortex.—The evidence that the primary sensory area of the cortex is essential to sensation is twofold. Destruction of this area results in the loss of sensations, whereas injury of other areas, such as those immediately surrounding the primary centers, does not eliminate sensations. Destruction of the total primary visual area results in blindness; destruction of part of the area results in partial blindness.

Whenever this area is wholly or partly removed the result is a loss of visual sensations, in whole or part. When the primary visual area is uninjured but the area surrounding it is destroyed, the result is not blindness, but inability to recognize or comprehend the object which provides the visual stimulus. The subject is aware of (conscious of) a patch of color of a certain size but he cannot recognize it as an orange; he *has no idea* what the stimulating object is. One patient called a clothes-brush a pair of spectacles, an umbrella a plant with flowers, an apple a portrait of a lady. Complete destruction of the outlying parts would result also in "word blindness," a condition in which the subject really *sees* (is conscious of) the word, but cannot interpret it. The symbol has no more meaning than a Chinese character to an American child. The patient might also be unable to recognize colors, his friends, his house, and other objects, although seeing them. The visual stimulus arouses but one conscious response, the sensation. No other conscious reactions—percepts, images, memories, thoughts—occur.

Removal of the cortex surrounding the primary auditory area results in similar losses of conscious reactions. The subject is aware of sounds but unable to interpret or comprehend them, unable to tell whether they are sounds of the human voice, a piano or a passing automobile. Removal of small portions of the surrounding areas may result in inability to recognize tunes, or to understand spoken words, or in some other limited loss of comprehension without any defect of the primary capacity to hear sounds.

Removal of the regions surrounding other primary sensory areas results in similar disturbances. The patient may be able to smell, taste, feel with the hand, but

no conscious reactions beyond the bare sensation are experienced.

Sensations.—Sensations consequently must be a particular kind of conscious reaction distinguishable from other mental activities which constitute recognition or perception of objects, recollection of, or ideas about objects. Sensations appear to be the first conscious reactions occasioned by external stimulation, since they have as their "seat" the areas first reached by the incoming nerve impulse. It is important to realize that they are reactions—to see, hear, taste, smell, or experience hot, cold, pressure or pain is to react to a stimulus. Sensations do not occur spontaneously without a cause. They are not things or processes within us which are brought into prominence by some type of self-activity or by some mysterious power of the "mind." They are, like movements, the results of activity occasioned by definite stimuli.

Other Conscious Reactions.—The sensation is the first conscious reaction, shortly followed by others. Each primary sensory area is profusely connected with other parts of the brain, thus making it possible for nerve impulses to be switched off in almost any particular direction, to reach almost any other region of the cortex, or to be distributed at once along many different routes. It is probable that removal of the areas surrounding the primary sensory centers cuts off all or most of these connections with other parts of the brain, thus eliminating all reactions, conscious or otherwise, which are dependent on more remote brain areas. The cases just mentioned, in which removal of the region immediately surrounding the primary sensory area resulted in the elimination of recognition or perception of the stimulating object, do not necessarily prove that the area removed was the only one

involved in comprehension. The pathways which run through these areas are essential but not necessarily sufficient. To destroy them may result merely in cutting some of the links in a continuous chain of neurones, all of which may be involved in a complex mental response.

The localizations of the conscious activities that follow sensations might be determined by starting at some re-

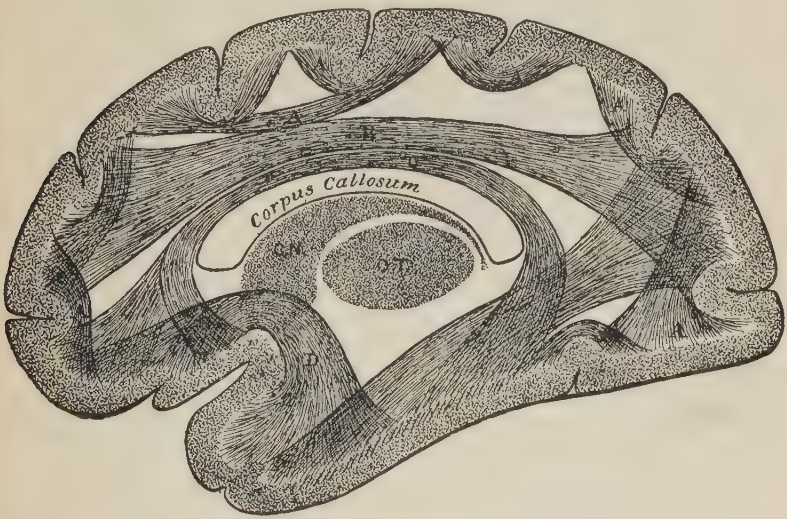


FIGURE 19. Bundles of neurones connecting the various parts of the brain. The part marked *Corpus Callosum* represents huge bundles of neurones interconnecting the two cerebral hemispheres. (From Woodworth's *Psychology*, after Starr.)

mote area, removing portion after portion, working in the direction of the primary sensory areas, determining after the removal of each part, what conscious reactions remained and what ones were abolished. This type of investigation, to be of value, would have to utilize human subjects, an enterprise which is obviously impossible. Such data as are available have been secured by studies of individuals who have lost portions of the brain as the

result of surgical operations, accident, or disease. Such cases have been too few in number and too varied in kind to yield very significant evidence, but they indicate, for such conscious reactions as percepts, recognitions, memories, imaginations and ideas, dependence not upon sharply defined areas but upon tracts penetrating variously all parts of the brain.

The Complexity of Brain Action during Thinking.— The probable complexity and extensity of brain activity may be illustrated by an adult's reactions to the printed word *apple.* The stimulus, a group of light waves, strikes the retina of the eye activating a nerve impulse which, on reaching the primary visual area, arouses certain neurones whose activity is somehow correlated with a sensation. The individual then *sees* a series of little black marks on a white ground. The sensation is merely this awareness of black and white. But almost instantly, at an interval too brief to be appreciated, the subject comprehends, or is aware of, the meaning of the word. He at once thinks of *appleness,* which means probably a fleeting consciousness of a round, colored, hard, odorous, edible object. Probably this really complex consciousness involves certain neurones running off toward the olfactory area, others toward the gustatory area, others toward the skin or body sense area, and others to intermediate regions. The perception of the word would thus involve an extensive, complex pattern of neurones. Each percept involves neurones in many brain areas. Different percepts depend upon the same general areas, but the patterns of particular neurones concerned are as numerous as the percepts themselves.

The act of perception is usually prompt. It is the almost instantaneous awareness or recognition of the stimulating object or event. In the present illustration,

on seeing the word "apple," one at once becomes aware of its significance, and the percept may be promptly followed by a series of thoughts or ideas. One may think of the kind of tree on which the fruit grows, of the appearance and number of such trees in an orchard familiar to childhood, and then of related childhood events. The percept leads to an idea, which leads to another idea, and so on. The whole series may in one case constitute a reverie, in another, imagination, and in another, purposeful thinking. In any case, the continuity, despite the rapidity with which thoughts succeed each other, is the significant matter for which a neural basis should be suggested.

Each thought in the series is paralleled by the activity of a complex pattern of cortical neurones which is not sharply localized, but widespread. The activity of one group of neurones, itself a reaction, leads to activity of another group, and so on. Thus each brain reaction becomes the stimulus which activates another brain reaction in somewhat the same manner as, in writing, the muscular acts made in one moment become the stimuli which occasion the acts of the next moment. And just as the series of acts in writing constitute a complex, rapid and apparently smooth continuity, so a train of associated ideas seems more like a flowing stream than like a series of distinct reactions. Actually, however, the stream of thought corresponds to a series of neural reactions, each caused by another preceding reaction, one following another with great rapidity.

One conscious reaction may lead to another associated conscious reaction, but this is not all. A conscious response may lead to muscular and glandular reactions as well. It is typical of the human individual to act after having perceived the situation or after having *thought*

about the situation perceived. Conscious activity is the antecedent of much of human activity, a fact that will appear more clearly after a consideration of the motor area of the brain and its relation to the areas primarily involved in conscious life.

Localization of Motor Functions

The Frontal Lobe of the brain, which occupies the whole region in front of the Central Fissure and above the Fissure of Sylvius, is mainly motor in function, in the sense that therein are the neurones most immediately concerned in directing nerve impulses downward through the mid-brain and spinal cord to issue into muscles and glands. In a long narrow strip of cortex immediately in front of the Central Fissure, running from the top downward to either temple, are contained the ends of the motor neurones which lead to the organs of response. This area, which we may call the *motor area,* is comparable in certain respects with the primary sensory areas. The latter are the regions to which all incoming neurones lead; the former is the area from which practically all outgoing neurones issue. Destruction of the primary sensory areas eliminates consciousness and all action which follows it, whereas destruction of the motor area leaves consciousness intact but eliminates the motor response. Thus, destruction of the motor area would render the patient incapable of speaking a word which he can see and recognize, of running his typewriter, of properly handling a knife and fork, of catching a football, and of writing, even when he is capable of perceiving and thinking about these objects and the situations in which they are encountered. Complete destruction of the motor area, by cutting off the motor connections between the

brain and the organs of response, would eliminate acquired acts and what is usually called *voluntary action*, by which are meant responses whose immediate antecedent is conscious activity.

Destruction of the motor area does not result in complete paralysis, since the reactions of the spinal level, the reflexes, and those of the mid-brain level, the more complex unlearned reactions, can still be made when proper stimuli are provided. The individual can vocalize, chew, swallow, walk, jerk away from pricks and burns, but he cannot speak English, sing an old song, handle machines and perform other learned or voluntary acts.

Localization in the motor area, as in the primary sensory areas, is fairly exact. The top portion of the brain area is connected with the muscles in the lower limbs, the bottom portion with muscles of the upper limbs and head and throughout, the brain areas and the connected body parts are in reverse order. Removal of parts of the motor area results in loss of voluntary activity in the corresponding parts of the body.

The fact that removal of the motor area results in the loss of voluntary activity does not prove that all learned movements are *located in* this region, any more than the fact that removal of the primary sensory area, which eliminates all more elaborate consciousness, proves that all conscious reactions are located in the primary area. In both cases, what happens is that the connections with other parts of the brain are severed, so that activities depending on neighboring or remote brain regions are cut off.

Connections of Motor and Sensory Areas.—The motor area occupies but a small part of the Frontal Lobe. All of the portion in front is richly connected with the sensory areas and the other posterior portions of the

cortex assumed to be involved in conscious life, as well as with the motor area. Impulses come in at the primary sensory areas, are distributed through the posterior lobes, then over to the Frontal Lobe, and finally, by way of the motor area, are discharged into the organs of response. During the transition, conscious states, sensations, percepts and ideas may arise and, in completing the circuit, the brain is engaged much as a whole. All parts are essential to successful activity, a fact which may be illustrated by the connections involved in human speech.

Suppose we ask an individual to repeat after us the sentence "Where is my hat." If the primary auditory area were destroyed, he could not repeat the sentence because he would be unable to hear it. If this area were intact, but the surrounding areas removed, he would hear the words, but they would be a meaningless jargon of sound and consequently it would be impossible to repeat the sentence. If all of the sensory and surrounding areas were unimpaired, the subject could hear and understand the spoken words and also think of them, but still be unable to say them when certain parts of the Frontal Lobe in front of the final motor area were destroyed. In such cases the subject may know well enough what words he wants to say but he is unable to pronounce them. He is not incapable of speech and hears what he himself says, but it is impossible to get the right words out. The fore part of the Frontal Lobe is apparently concerned with the combination and coördination of movements which compose our complex learned or voluntary acts. Finally, suppose that the whole brain is intact except the final motor area. In this case the individual may hear the words and think of exactly what he wishes to say, and in addition to this, the impulses may be properly coördinated in the fore part of the Frontal Lobe, but he is

unable to speak voluntarily at all. The connections leading from the motor area to the vocal organs have been cut, with the result that all learned or voluntary action is abolished. The individual's speech organs are not paralysed, inasmuch as the mid-brain and spinal reactions may be made. The individual may cry out when frightened or injured, but the complicated acquired forms of speech are eliminated.

Analogous difficulties in the execution of other types of complex reactions may be caused by brain defects. In a disorder called "motor apraxia," the patient, because of destruction of the Frontal Lobe in front of the final motor area for the hands and arms, may recognize the object and think about it, but he cannot get the proper organization of movements to handle it. When the final motor area itself is injured, he can recognize the object and intend the right movements of manipulation, but they do not occur. Disturbances earlier in the chain of events, in the region surrounding the primary sensory area, make recognition and hence proper movement impossible. Destruction of the sensory area results in total inability to see the object.

Thus there are four steps in the transition of nerve impulses through the brain: first, sensation, which means reaction of the primary sensory area; next, perception and thought, which mean activity of widely spread areas which compose the greater part of the posterior cortex; third, the organization of and preparation for a complex motor response, which involves the larger portion of the Frontal Lobe; and finally, the collection of the nerve impulses in the final motor area, where they are discharged by way of the mid-brain and cord to the organs of response. Defects anywhere along the line will occasion disturbances or disability.

There is often a very perceptible delay between perception and final movement, a delay caused by a train of thought. For instance, if a subject is asked to "Give the best synonym for the word *eloquent,*" he may promptly perceive the words and grasp the meaning of the request, but he may need to think some time before deciding what motor reaction to make. Having finally decided what to respond, the movement pattern is organized and action results. Again, one may perceive that a gateway is closed and proceed to think things over for a time before deciding upon and taking a line of action. In these cases perception is followed by thinking, for a period long or short, out of which action may eventually issue.

Conclusions

In all of these illustrations, both the intimate relation of conscious states with movement and the complexity of brain activity are apparent. In what appear to be rather simple matters, such as reading or repeating a few words, all parts of the brain are involved. Such functions, and similarly most of thousands of other acquired abilities, are not localized in any one small area. We know rather definitely where the nerve impulses come into and where they leave the cortex, but between entrance and exit, where conscious states arise and where the complex patterns of discharge are organized, the complexity of neurones concerned is baffling.

If there is little likelihood of definite brain localizations for percepts, images, memories, ideas, emotions and other complex conscious processes, there is still less possibility of precise localization of such complex traits as executive, selling, or teaching ability, the doctrines of the Phrenologists notwithstanding. Mental traits such as sagacity,

attentiveness, and intuitiveness have no compact localization, nor have temperamental and character traits, such as vivacity, cheerfulness, trustworthiness, honesty, sensitivity, or tendencies to love babies, seek power or enjoy music. Many parts of the brain are engaged in most of the single reactions of thought, skill, or sensibility.

While the evidence, then, that brain action is a necessary correlate of consciousness is substantial, study of the brain, beyond the identification of sensations, contributes but little to the task of disentangling our complex conscious responses. Other methods must therefore be utilized in the study of conscious experiences. To these methods and the results obtained by their use, the next chapter will be devoted.

QUESTIONS AND EXERCISES

A.

Complete the following sentences:

1. There are.........kinds of muscles, ...muscles and ....muscles. The........muscles are often called........ muscles. The..........are connected directly with the.......... neurones which issue from the central nervous system, but the ....muscles are connected directly with neurones of the ....system which are.........by..........with the motor nerves.

2. A nerve impulse may cause a muscle to..........as well as to..........

3. The muscular response to a single stimulus is called......... A series of rapid stimuli produces..........

4. The smooth muscle differs from the..........muscle by reacting more........and by maintaining........for a.......... time.

5. There are..........kinds of glands; ....glands and ....glands. Glands are immediately connected with the ....neurones. The function of the gland is.......... The ....glands secrete into..........or..........whereas the

..........glands secrete directly into the......................

6. Glandular activities may play an important role in determining such human traits as.........., ...and..........

7. The brain is divided into two........separated by a........ Each..........is called a..........

8. The brain is divided into..........lobes, the..........lobe in front, the..........at the back, the ....lobe on top and the..........at the side.

9. Two important clefts or fissures of the brain are the........ and the..........

10. The..........part of the brain is motor, the..........part is..........

11. The first conscious..........is called a..........

12. All conscious states are..........to..........

13. Thought involves........different.........of the.........

B.

1. Where is the "seat of the mind"?

2. Could the cerebral cortex be considered a connecting as well as a responding mechanism?

3. Can you find any evidence from the facts of evolution which would support the belief that the development of the nervous system is correlated with the development of consciousness?

4. Give three differences between the phrenological conception of brain localization and the conception presented in the text. Show how the scientific method enables us to discover the truth of the matter.

5. Can you find an example of a stimulus which causes a reaction but does not, finally, issue into actual muscular response?

6. Can you find an example of an action which was not caused by some external or internal stimulus?

7. Show how the sensations which we get from the sound of an automobile horn, the smell of a rose, the taste of lemonade, the feel of a round object, differ from the perception of these objects.

8. What differences or distinctions can you find between muscular and glandular responses on the one hand, and cortical reactions on the other? If genuine differences exist between these groups of responses, does that fact imply the inadequacy of the "reaction hypothesis"?

9. Would study of the glandular reactions be conducted by the *introspective* or the *objective* method?

10. Draw a sketch of the brain and indicate the several sensory areas.

REFERENCES

K. Dunlap, *An Outline of Psychobiology*, second edition, 1920, and J. B. Watson, *Psychology*, 1919, give good general treatments of the reacting mechanisms. For further details concerning muscular activity, any good physiology, such as W. H. Howell, *A Textbook in Physiology*, sixth edition, 1915, may be consulted. For a non-technical treatment of the glandular mechanisms, see B. Harrow, *Glands in Health and Disease*, 1922. For details of localization of functions, consult Ladd and Woodworth, *Physiological Psychology*, 1911.

CHAPTER V

CONSCIOUS STATES AND PROCESSES

In the preceding chapter, we found that consciousness is intimately bound up with activity of the brain, but that study of the nervous system yields only a partial analysis of mental life. To secure more complete knowledge of the various kinds of conscious states, to describe, classify and analyse them into elements, psychology has utilized mainly the *method of introspection,* some of the limitations of which were mentioned in Chapter I.

Consciousness is always a process, it is moving and changing, it never stands still for observation. Like the scenes on a moving picture screen, some of the background may remain fairly constant, but changes of setting, radical or slight, may be made at any time and the leading characters may appear and depart abruptly. Typically, events sweep on in ever changing complexes. If consciousness could be held up, as one may stop the moving picture camera and throw a single picture, a cross section of the activity, on the screen for prolonged observations, the task of describing and analysing its contents would be greatly simplified. This, however, is impossible. One must either observe the complex events as they appear, that is introspect, or recall and reflect upon them after they are gone, a method of observation usually termed *retrospection*, a looking backward, a study from memory.

Consciousness may perhaps be better compared to an orchestra. At each moment the music is a very complex

whole, and music exists only when in process. As soon as the instruments become inactive, the music ceases. Nothing is left to examine. The best one can do, if he is interested in studying the details of a particular phase, is to have the combination of sounds prolonged or repeated. In the laboratory, the introspective psychologist attempts, by careful arrangement of conditions, to prolong a conscious process and to repeat it as often as needed. He may attempt to call to mind each of the several steps in solving a practical problem, repeatedly holding up and working over some of them, while endeavoring to observe the whole to sift out the component parts and to note their similarities and differences.

Primary Conscious States

Consciousness is exceedingly complex, made up of many elements, like an orchestral selection. To the uninitiated, the music is appreciated only as a rather vague whole. To the trained musician, the complex consists of units of sound from the violin, the cornet, the drum, which enter in an intelligible way to make up various patterns that form a harmonious whole. The trained musician may go further. He may analyse the sound of the cornet or violin into a composite of certain fundamental tones and overtones. In an analogous manner, the introspective psychologist by prolonged experience comes to recognize in the stream of conscious processes, a number of units which fuse and combine in an infinite variety of ways. Having discovered certain types of consciousness, he may attempt to analyse them into more minute elements. The irreducible elements are termed *primary conscious states* or *elements of consciousness,* or the *elementary content of consciousness.*

Sensations

Among the most readily recognized conscious states are those which constitute the awareness of qualities of objects or events. We gaze at an orange and become aware of its color, sniff and become aware of its odor, apply our tongue and experience its sweetness and sourness, touch it and realize its coldness and pressure. The orange is an object which arouses in us various sorts of conscious reactions, and such responses are called sensations.

Sensations are Irreducible.—The sensation, as we found in the preceding chapter, is the first and simplest conscious response to a stimulus, immediately followed in all individuals, except the newly born infant perhaps, by other more elaborate conscious responses. The adult finds it very difficult, if not impossible, to distinguish the sensation from other conscious reactions which follow at an imperceptible interval of time. Visual sensations, for example, are the barren awareness of purple, red, orange, yellow, green and blue. It is very difficult to dissociate mere awareness of these colors from awareness of the objects—the necktie, apple, orange, lemon, leaf or sky—which provide the stimulus. Auditory sensations are meaningless sounds or noises, without awareness of the things or events—the horn, wagon, phonograph, or falling board—which produce the stimuli. The introspective expert finds it possible to analyse these single conscious states from the others which accompany or follow them, and he finds it impossible to further dissect them or to reduce them to lower units. Sensations, then, are irreducible conscious elements or primary conscious states.

Types of Sensations.—Sensations are usually classified according to the sense organs in which the nerve impulse arises. They are usually further subdivided according to

their introspective resemblances or according to the stimulus which occasions them. Few classes are as yet thoroughly established. A classification in outline follows:

A. Sensations from sense organs aroused by external stimuli.

1. From the eye: visual sensations, such as, red, green, blue, yellow and shades of gray.
2. From the ear: auditory sensations or tones embracing a wide range of qualities.
3. From the mouth: gustatory sensations or tastes of which sweet, sour, bitter and salt are considered irreducible.
4. From the olfactory area in the nasal cavity: olfactory sensations or odors, of a great many varieties, not as yet well analysed or classified into elements or types.
5. From the skin: warm, cold, pressure, pain, each the result of the activity of particular sense organs.

B. Sensations from sense organs influenced by internal stimuli.

1. From the semicircular canal, the saccule and utricle adjoining the inner ear: dizziness or giddiness, possibly but not certainly.
2. From the muscles: pressure, warm, cold and pain.
3. From surfaces of joints: pressure and pain.
4. From the alimentary canal, blood vessels, lungs, heart and other visceral organs: pressure, warm, cold and pain.
5. From the nervous system itself: pain.
6. From the sex organs: pressure, warm, cold, pain, and possibly others.

The actual stream of consciousness in the adult, seldom if ever, offers a single sensation at once. Even in lifting a small weight we may experience sensations not only of warmth, cold, and light pressure, but other sensations from muscles, ligaments, and joints, from the arm as well as from the fingers. Fused with these are floods of sensations from other parts of the body, as well as odors, sounds, and sights from other external stimulation.

Compounds of Sensations.—In everyday experiences, we are prone to confuse *compounds of sensations* with the single elementary sensations. Hunger, thirst, nausea, aches, and other organic and muscular sensations are compounds or complexes of hot, cold, pressure, and pain, each in various proportions. What we call the taste of an onion is a compound of odors, tastes, pressures, and pain, and of these the odor is most prominent. But for differences in odor, raw potato and apple, slightly bitter water and coffee, roast beef and lamb could scarcely be distinguished.

The Content of Thought

Sensations are conscious reactions which appear when a nerve impulse, originating in a sense organ, reaches the cortex of the brain. Sensations are never experienced except as reactions to a stimulus which affects some sense organ. In ordinary thought, in remembering, imagining, day-deaming or reasoning, conscious activities are experienced that are obviously not sensations. They are conscious states which appear in the absence of direct sensory stimulation.

Images.—If one closes his eyes, while comfortably seated, and proceeds to examine his thoughts as they flow, it is at once apparent that the content is both com-

plex and varied. Among other things, most observers find that they experience conscious states that are a great deal like sensations. They can think of red when the objective stimulus is absent, and the color thought of is something like the real sensation, although it is usually less sharp and clear, less vivid, less definite in shape, less stable. It may come and go, shift from one size to another, or from one degree of vividness to another; it is more slippery, evanescent and difficult to study, but nevertheless unmistakably similar to the genuine sensation. Such conscious reactions, similar in appearance to sensations but obviously differently aroused, are called *images*.

Types of Images.—Inasmuch as images are similar to sensations, they are usually classified in the same way. Thus we have

Images of sights ....Visual Images
Images of sounds.........Auditory Images
Images of touch..........Tactile Images
Images of muscular, ligament and joint pressure.. Kinesthetic Images
Images of hot or cold ....Thermal Images
Images of tastes ....Gustatory Images
Images of odors..........Olfactory Images
Images of pain...........Pain Images

Symbolic Imagery.—Visual, auditory and kinesthetic images are most commonly found during recollection or thought. Often the images utilized in thinking are not representations of the qualities of concrete objects or events but of *symbols* which stand for them. Most people, especially educated people, find in the course of thinking a great many images of words, or *verbal imagery*. They notice fleeting images of the visual

appearance, or the sound of the word or the muscular feel of saying the word, or sometimes two of these, or all three at once. Others report different forms of symbolic imagery. A certain druggist finds that when he thinks of "prescription," he doesn't see an image of a bottle, of a mixture of liquids, or a piece of paper with writing on it or any other concrete thing, nor does he mentally see, hear or say the word, but he has a fleeting visual image of ℞. The student of mathematics may think in symbols peculiar to that subject, in sketchy impressions that stand for angles, infinity, etc. The stenographer may think in images of short-hand symbols. Most of us employ upon occasions symbolic images which are peculiar to ourselves.

Some individuals find that they have a wealth of 'kinesthetic' images, that is, images of the body's own activity as experienced through the senses in the muscles, ligaments and joints. Recall of the sensations of speaking a word, nodding the head, grasping a pencil or lifting the arm, are samples of kinesthetic images. Many seem to find that in recalling "cow" for example, they do not see a cow in the mind's eye or hear a cow "moo" or see the word *cow*, or hear themselves or some one else say *cow*. What they experience are images of the muscle, ligament and joint, i.e., of the kinesthetic sensations of saying or writing *cow*, or of eye movements in looking at the word or the real cow.

The kinesthetic, visual and auditory images of symbols may be exceedingly brief, fragmentary and obscure, but they are always similar to the sensations occasioned by seeing, hearing, speaking, and writing the symbol. They are somewhat like weak revivals of actual colors, sounds, tactile, muscular or other sensory qualities.

According to some introspective psychologists, all

memories and ideas, all thoughts are made up of images combined in various patterns. That is, all of the *facts* thought about may be reduced to complexes of conscious reactions of the sensation-like type. My ideas or thoughts of Fred, my watch, my hat, or of men, watches, or hats in general, of justice, liberty, aboveness, number, and so on, are, they contend, really combinations of images, though these images are often vague and fleeting.

Non-sensory Ideational Elements.—That images are irreducible conscious elements and that they are generally found during thought is not disputed, but the statement that images are the only conscious data is denied however, by other introspective workers. There are some who believe that thought often includes more than sensation-like images. Ideas especially of *relations,* such as bigness, under-ness, around-ness, nearness, similarity; ideas of *abstract qualities,* such as hardness, squareness, faithfulness, five-ness, charity, and other *complex ideas* such as those of energy, The Law of Gravitation, the reaction hypothesis, heredity, or Democracy, cannot, they believe, be wholly accounted for in terms of images. Some assert that in the instant that certain ideas occur to mind, there may be no mental imagery which is like any kind of color, sound, pressure, or other sensation. The idea comes, as it were, pure and simple. It is a conscious reaction, the very essence of thought, but it is not accompanied by sensation-like imagery. They would, therefore, propose that images are not the sole *ideational elements.* There are others, although they have not as yet yielded to very satisfactory description by the introspective method.

Summary.—In summary, we may say that sensations are introspectively unanalysable and therefore primary conscious data, and that images, being irreducible, are

also primary conscious states, and that it is probable that there are important conscious elements of the cognitive type, that is, important ideational elements that have not as yet been fully identified and described. Thought is extremely complex and a complete analysis awaits future research. Meanwhile, we will use the term *ideational elements* when referring to the content of thought, of memory, imagination, etc., including under this term both images and non-sensory conscious data but excluding, of course, sensations.

Feelings

Pleasantness and Unpleasantness.—In addition to sensations, and ideational elements, many introspective psychologists include among the primary mental states, the *feelings.* Not only are we aware of red, blue, salt, and pain, we also *feel* the agreeableness or disagreeableness, the *pleasantness* or *unpleasantness* of the sensation. Just what these feelings are cannot be readily portrayed in words. One can understand them only by examining the content of consciousness when one is aware of the pleasantness of a sweet taste, or the unpleasantness of a bitter taste, or when one finds one voice pleasing, another displeasing, or when he finds one color combination agreeable and another disagreeable. Ideas, too, may have a tinge or background of feeling. The thought of a social blunder may be decidedly unpleasant, while the thought of the victorious finish of a footrace may be very pleasant.

In everyday life we speak of many varieties of feelings, such as feelings of fatigue, feelings of stiffness, feelings of anger. We say "I feel good" or hungry, sorry, happy, excited, energetic, anxious and so on, as well as pleasant

or unpleasant. In these everyday usages of the term, "I feel" becomes essentially equivalent to "I am conscious of" or "I am aware of" and what we are aware of is some bodily or mental condition. Most of these "feelings" turn out to be groups of sensations. In psychology, the term feeling is used in a technical sense. Pleasantness and unpleasantness are primary feelings. Nothing else is a feeling in the sense that it cannot be reduced to other elements, such as sensations. At least, this is the opinion of many authorities.

Feelings and Sensations.—Pleasantness and unpleasantness are not identical with sensations although the two are readily confused. In particular, unpleasantness is easily confused with sensory pain. Pain is a definite sensation occasioned by the stimulation of a particular kind of sense organ. There is no sense organ, however, for either pleasantness or unpleasantness. These feelings may accompany any sensory experience. Pain is usually unpleasant just as sweet is usually pleasant, but both pain and sweet are sensations. When one is satiated or nauseated, sweet may be unpleasant, and pain is probably not always unpleasant as when a boy gently pokes a sore tooth. In pathological cases, extreme sensory pain seems to be distinctly pleasant, although it is still pain. The taste of salt is sometimes pleasant, sometimes unpleasant, and so with pressures, tones, odors, and other sensations. While some are generally one or the other, few are invariably accompanied by the same feeling and these variations make it clear that sensations and feelings are not identical.

Feelings and Emotions.—Feelings are also easily confused with emotions, such as anger, fear, joy, or sympathy. Fear, for example, while usually unpleasant, may be accompanied at times by a pleasant feeling, as when

one is riding in an airplane, hunting a wild beast, or shooting the rapids in a skiff. Anger is usually unpleasant but sometimes pleasant; dogs are not the only animals that seek a quarrel for the pure pleasantness of it. At times one may find sympathy for others rather unpleasant, and may give alms or relief to save oneself the feelings which accompany sympathy, but on other occasions, sympathy may be deeply indulged—perhaps sympathy for oneself—precisely because it is pleasant. The common emotions then are not the same as feelings inasmuch as they may be accompanied sometimes by one, again by another feeling.

Theories of Feeling.—Some authorities have contended that pleasantness and unpleasantness are not irreducible conscious states but complexes of organic sensations. They assume that most reactions, whether conscious or motor, are accompanied or followed by slight, but probably important internal or organic changes. One group of internal changes is experienced consciously as pleasantness, another group as unpleasantness. A sweet taste is usually accompanied by inner changes of the first sort, a bitter taste by changes of the second sort. The thought of a friendly act arouses organic changes which are pleasant, while the thought of a stinging rebuke, arouses the unpleasant variety.

This is an attractive theory, but the difficulty is that no one has been able to identify the two groups of internal changes. Nearly every experience is accompanied or followed by various types of slight organic changes, but those that have been identified do not appear to fall neatly into two distinct groups, one to correspond to pleasantness, another to unpleasantness. It is, of course, possible that the really significant changes are extremely subtle and await discovery. But many think such a

discovery unlikely for the reason that introspective study of the feelings shows very little that is much like familiar organic sensations. The feelings, they contend, are utterly unlike combinations of known sensations. They are a radically different kind of conscious experience that cannot be broken up into anything more elemental.

Search for the physical basis of pleasantness and unpleasantness has not been fruitful. No particular area of the cortex is known to be associated with the feelings, although several by no means convincing bits of evidence have been presented to the effect that parts of the mid-brain, or parts of the Frontal Lobe, or both together are primarily concerned. That the feelings are not definitely localized in the brain is not evidence against their reality inasmuch as other conscious processes, such as images, are not known to be dependent upon any precise brain area.

According to several theories, the explanation of feelings is to be found in the condition of the neurones themselves. It is assumed that activity of the neurones when they are in one kind of condition results in pleasantness, and when in another kind of condition, in unpleasantness. Precisely what these inner conditions of neurones may be is not known. According to one theory, that of Thorndike, the condition may be expressed roughly as a readiness or unreadiness to act. When neurones are ready to act, exercise results in pleasantness, when unready to act, activity is unpleasant. When we are ready to eat, sleep, talk, to do so is pleasant. When the neurones concerned in these activities are unready, forced activity results in unpleasantness. It has been furthermore assumed that when neurones are ready to act, for them not to act results in unpleasantness. Thus when the neurones concerned in tasting salt are ready to act,

to taste salt is pleasant, to fail to taste salt is unpleasant. When one is unready to taste salt, its taste will be unpleasant. Although the actual state of affairs in neurones, when ready and unready, is unknown, this theory seems to harmonize very well with introspective findings, such as the fact that an experience is sometimes pleasant and again unpleasant, the fact that nearly every reaction is "toned" to some extent by one feeling or the other, and finally, with facts later to be observed concerning the organism's tendency to avoid repeating an act which is unpleasant and to seek and repeat an act which is pleasant.

Degrees of Pleasantness and Unpleasantness.—Feelings, finally, are experienced in various degrees, ranging from the most extreme unpleasantness through a zero or indifference point to the most extreme pleasantness. Severe sensory pain, nausea, or the thought of an impending business failure would usually be rated as highly unpleasant. The taste of dry bread or the idea aroused by an old joke might be indifferent, neither pleasant nor unpleasant. The taste of fruit when hungry, the sound of music, the thrill of flattery, or the thought of a holiday might be highly pleasant.

Summary of Primary Conscious States

The introspective analysis of the content of consciousness is found to be difficult, so complex is the whole and so evasive the parts. Among the specialists in this field there is some disagreement, but on some points all opinions are in harmony. It is generally agreed that *sensations* are primary, irreducible mental states. There is unanimous agreement also that images are primary mental data which may be described as similar in appearance

to sensations without being identical with them. Some believe that images are the sole content of thought whereas others believe that there are ideational elements of a non-sensory character. That feelings of pleasantness and unpleasantness are primary conscious states, differing from sensations, images, and ideational data of a non-sensory sort, is believed by many but not by all authorities. On the whole, the preponderance of evidence is probably in favor of assuming at least these four types of conscious elements—sensations, images, non-sensory ideational data and feelings. With sufficiently refined methods it is possible that the non-sensory ideational data may be analysed into two or more elements.

Complex Mental Processes

The introspective analysis of consciousness was achieved by study of complex streams of conscious activity. From a practical point of view, we are usually more interested in the complex processes than in the elements. In everyday life we talk of perceiving a thing or event, of remembering a fact, of imagining, of dreaming, of reasoning. We speak of emotions, impulses, ideas, and memories. In all of these processes, the conscious content is complex, made up of the primary mental states in innumerable combinations and fusions. In the remainder of the chapter, the composition of several complex mental processes will be suggested, briefly in most instances, inasmuch as more complete discussions will appear in later sections.

Percepts

A percept is the outcome of an act of perception; the percept is a conscious state. Perception, we learned in

the preceding chapter, follows sensation, but the latter is usually prolonged and fused with the former. The sensation is the awareness of the bare quality of an object; the percept is immediate recognition of the object, a conscious reaction more complex and of a different sort than sensation. Introspective examination of the content of consciousness during the act of perceiving an object, shows both sensations, images and, according to some, ideational elements of the non-sensory sort, all combined or fused to appear as one unit. In perception, then, no new conscious states are found; only sensations and ideational elements.

Emotions

Love, hate, fear, jealousy, anger, joy, sorrow, are familiar emotions. They are conscious, in fact, most vividly conscious, and yet diffuse and indefinite in comparison with most sensations, percepts and ideas. They have a subjective reference; they are felt as if in us, whereas colors, sounds, and odors are felt as if outside the body. According to the now famous James-Lange Theory, formulated at about the same time over thirty years ago by the American psychologist William James and the Danish physiologist Carl Lange, the emotion is not a new kind of conscious state but essentially a complex flood of sensations from disturbed activities of the body. The emotion is a blend of sensations from the skin, muscles, blood vessels, stomach, heart, intestines, lungs, internal glands—from a great many different parts of the body.

Some stimulus, such as a clap of thunder, an aggravating man, a fearful animal, or an idea of these or other things, first greatly disturbs the inner workings of the

body. These disturbances stimulate thousands of the sense organs which occasion a torrent of sensations. The complex of sensations *is* the emotion. This view seems to be essentially correct, as we shall see in a later chapter devoted entirely to the emotions.

Impulses and States of Readiness

When one is about to sneeze, yawn or cough, one may experience a conscious *impulse.* If some one makes an offensive remark, one may feel an impulse to strike or make a cutting retort. When hungry or thirsty, one may experience an impulse to eat or drink. If the act of sneezing, coughing or striking occurs promptly, following its adequate stimulus, the impulse is scarcely observed; it is in the event of a delay in the response that it becomes vividly conscious. Thus, if it is impolite to sneeze, yawn or speak, the impulse becomes clearly conscious.

Impulses are distinctly subjective experiences, somewhat similar to the sensations of tickle, mild pain or the combinations of organic sensations such as those comprising strain or ache. The former have, however, a peculiar quality which may be described only by saying they are impulsive. May this impulsive character be reduced to the primary conscious states already observed?

Most probably impulses introduce no new conscious data. Those connected with the acts of sneezing, coughing, and the like, consist mainly of sensations from partly aroused muscles and in some cases, glands. When a person is on the verge of a sneeze, there is really a considerable activity under way, activity which is a preparation or a preliminary adjustment for the final response. The individual takes in breath, the nostrils

widen, facial muscles contract, glands in the nostrils and eyes secrete. The sensations occasioned by all of these adjustments is the impulse. The impulse, being a group of sensations, is conscious, and the bodily condition which occasions the sensations is a state of readiness, or preparation for some act.

Impulses and states of readiness may precede any activity, such as eating and drinking, and other instinctive acts, whether simple, like jerking away the hand when it is pricked, or complex, like the impulse to fight when angered, to run when afraid, or to seize an attractive object. Impulses and states of readiness may precede acquired acts such as studying, playing tennis, attending the movies, or smoking a cigar. Any reaction whatsoever may be preceded by a state of readiness and the corresponding conscious impulse.

There are probably impulses which depend not upon the partial activity or state of readiness of muscles and glands, but upon a slight arousal of cortical neurones concerned in ideas. Thus one may, in mental arithmetic, be disposed to add rather than to subtract or divide. One has what is sometimes termed a *mental set* in one direction which favors further mental activity of one sort rather than of others. Thus by means of preliminary instructions an individual may assume a mental set favorable to thinking of the opposites of a series of words rather than synonyms or vice versa, or to thinking of animals or plants or cities or rivers. The mental set is a preparatory reaction, or state of readiness, which is sometimes very difficult to analyse consciously, and which depends upon a slight arousal of certain neurones which constitutes an effective predisposition toward one kind of further activity, rather than other kinds. Insofar as the impulses may be analysed, they seem to consist

either of sensations or ideational elements of the sorts found in other states of consciousness.

Memory, Imagination and Other Thought Processes

The contents of thought are images and other forms of ideational elements as yet not clearly described. There are several types of thought or thinking, but the conscious elements appear to be the same in all. Whether we call the type of thinking memory, imagination or reasoning, is determined by criteria other than the kind of conscious data utilized, as we shall see in later chapters.

The Complexity of Conscious Activity

The fact that one's consciousness at any moment is complex has already been emphasized. As the reader sees this page, he may be conscious of the temperature and of various sights of the room, of sounds from a distance, of the weight of the book, of well-being or ill-being of the body, of muscular pressure and strain, of percepts of words and various ideas recalled thereby, of being pleased or displeased or possibly emotionally interested or disgusted with it all. Although it is necessary for scientific purposes to dissect a momentary consciousness into sensations, ideas and feelings, and to consider separately such combinations as percepts, emotions, impulses and memories, a full cross-section of consciousness would usually include all of these in any one of innumerable combinations. As Thorndike has aptly remarked: "Mental life is not like a series of solos, now sensations, now memories, now feelings; but it is

like the performance of the whole orchestra in which many sounds fuse into a total. One instrument may predominate for a time, but seldom, if ever, is it active alone."

QUESTIONS AND EXERCISES

1. Make up a set of 5 true and 5 false statements based on facts given in the text and try them on other members of the class.

2. When you go into your room tonight, stop for a moment before turning on the light and get an image of the objects in the room. Then illuminate the room and get the actual sensation. How do sensation and image differ? Imagine the view out the window, the sound of a book falling, the smell of a burned match, the feeling of stepping forward, the touch of silk or fur—and compare the sensations derived from these same objects or events. How do you know, in one case, that a real object is present—in the other that you are only "imagining"?

3. Compare the images which come to you during the reading of this textbook with the images you experience when reading a vivid descriptive poem. In either case, is there any other ideational element present?

4. Do you suppose images are ever present, of which you are not conscious?

5. Would you call planning a novel, reasoning or imagination? Planning a house, a dress?

6. Grade the following experience, on a scale for pleasantness in which the most extreme pleasantness is called 10, the most extreme unpleasantness — 10.

   Eating an olive.
   Smelling camphor.
   Hearing a loud conversation while trying to study.
   Barely missing a street car.
   Being told that you are "good looking."
   Insomnia.

7. Which primary mental states are most prominent, which less so in the following experiences:

   Extreme anger.
   Day dreaming.

Solving a problem in geometry.
Watching a theatrical performance.
Preparing for an examination.
Writing an examination paper.

8. Enumerate some of the main difficulties which all encountered in using the introspective method.

9. Analyse a recent dream into the primary mental states which compose it.

10. Suppose that after a hard struggle with yourself, you have made up your mind to do a distasteful task. How would you describe your consciousness (in terms of mental states and processes) at the time when the decision is made?

11. Do you think "mental set" has any influence in determining to which of a number of possible objects, we shall attend?

12. Can you think of an experiment by which you could determine the adequacy of the theory which explains feelings in terms of the neurones' readiness or unreadiness to act?

13. Illustrate the fact that emotions have a subjective and sensations an objective reference.

14. Look at a piece of candy, and experience fully the impulse to eat but withhold for a while the final reaction. Write an introspective account of the content of consciousness, describing as fully as you can, the elementary states which make up the impulse.

15. Have you ever mistaken an image for a sensation, or a sensation for an image?

REFERENCES

William James, *Psychology, Briefer Course,* 1907.
W. B. Pillsbury, *Essentials of Psychology.* Second Edition, 1920.
E. B. Titchener, *A Beginner's Psychology.* Second Edition, 1920.
R. S. Woodworth, *Psychology,* 1921, especially chap. XV, which deals with the problem of non-sensory ideational elements.
H. C. Warren, *Elements of Human Psychology,* 1922.

CHAPTER VI

THE ORIGIN, DEVELOPMENT AND GENERAL CHARACTERISTICS OF INSTINCTIVE ACTIVITY

If we had before us several newly-born infants for observation, it would soon be apparent that in the weight of the body, color of eyes, shape of the nose—in fact, in any anatomical feature we might single out—marked individual differences occur. In the sensitivity of the eye, ear or other sense organs, in the speed and force of muscular reaction, in the conductivity and modifiability of the nervous system, in the efficiency of heart action, in the glandular activities of digestion, and in resistance to disease, variations are apparent even at birth. How are we to account for these differences? Are they due to accidental factors, to differences in nutrition or in maternal activity? Are they in any way *acquired* before birth, or is there some other explanation of their existence?

What is known about pre-natal influence makes it appear improbable that most of the anatomical and functional differences which appear at birth are *congenitally acquired.* While severe illness, emotional disturbances, malnutrition, alcoholism, and other serious misfortunes of the mother may affect the child through the mother's impoverished or poisoned blood, and while the child may be directly harmed by infectious disease or by injuries before birth, these facts seem to prove merely that there is required a pre-natal environment

that will permit normal growth to go on. Given favorable conditions up to the time of birth, differences among infants will still appear; differences that are not congenitally acquired, but *inherited.*

Life begins with the fertilization of the ovum, a microscopic but very complex cell. Contained in the germ cell are certain elements or "determiners" out of which the various bodily organs and functions develop. Certain determiners grow into certain sense organs, others become particular bones, others become teeth, and so on. Even for the most minute traits, the color of the eyes, the shape of the lobe of the ear, a peculiar notch in a tooth, there exist determiners in the germ cell. Except for the occasional congenital disturbance of the severe types mentioned, the differences among infants which appear at birth are *native,* in the sense that they are the result of the unfolding, innate growth of determiners which existed in the germ cells from the beginning of life.

At the time of birth, however, almost no trait, not even the color of the eyes, is fixed in its final form. Growth is still going on; the eyes rapidly become a deeper blue, the bones lengthen, the face takes on new expression. Are these changes which take place after birth, like prenatal growth, largely an unfolding of innate traits, or are they now more largely determined by the influences, training or experiences provided by the much more variable and complex environment? As illustrations, we may consider the growth of the following human traits:

1. Anatomical traits
2. The capacities or functions of bodily organs
3. Types of reactions, such as grasping, sneezing, crying, fighting

The Growth of Anatomical Traits

The growth of height might be taken as an illustration of the development of an anatomical trait. Beginning at approximately zero height an average boy has grown

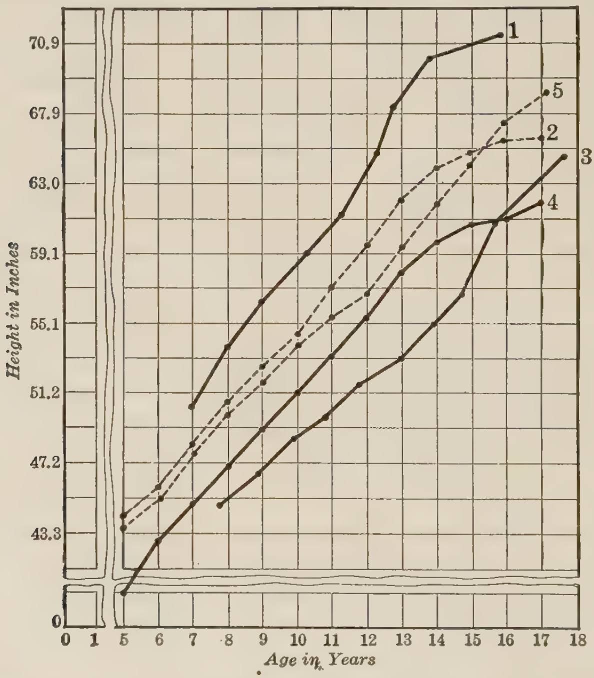


FIGURE 20. Curves of growth in height obtained by consecutive measurements of the same individuals. Number 1 is the curve for a boy reaching 5 feet 11 inches at maturity; 2 is a tall girl; 3 a short boy; 4 a girl, and 5 the average for many boys. (From Baldwin and Stecher. *University of Iowa Studies,* Vol. 2, No. 1, 1922.)

to about 20.5 inches at birth, to about 42 inches at the age of five, and from that time growth increases fairly uniformly until the maximum height of about 68.5 inches is reached in his seventeenth year or thereabouts. Different individuals show various curves of growth,

some less regular than others, some maturing later than others, and reaching different maximal heights, and these variations, as well as the rates and limits of growth are, in the main, determined by original nature, by elements which existed in the germ cells. Of course, the child will not grow as he should without proper food, sleep and exercise, and his development may be disturbed by disease, poisons and other harmful influences. But given a reasonably good environmental opportunity, the child matures in accordance with his inherited predisposition.

Other anatomical traits such as the color or size of the eye, the profile of the face, or shape of the pelvis are, like height, determined mainly by original nature. The growth of weight, while it shows a curve similar to that of height, except that it is more irregular, is more susceptible to environmental factors than is the development of most anatomical traits. An afternoon of violent exercise may reduce weight somewhat, without perceptibly affecting height. Malnutrition and most forms of illness have less effect on height than on weight. But here again, given a normal life, weight is largely an expression of native constitution; that is, if many children were given identical amounts and kinds of food, exercise, and sleep, and were free from disease, they would still attain different weights.

Growth of Capacities and Functions of Mechanisms

Sensitivity of the Sense Organs.—The sensitivities of the sensory mechanisms are fairly well developed at birth, although growth is rapid for two or three years thereafter. By the age of three, the organs are very

nearly as sensitive to stimuli as they will ever be, although it is probable that very gradual growth occurs until a maximum is reached in the late teens. Much the same curve of development is shown by the capacity to discriminate between stimuli; for example, between high and low notes, dark and light shades of gray, heavy and light pressure. The development of such sensory capacities seems to be determined largely by inner factors rather than by experience. Diligent exercise produces at any one stage some improvement, but the limit is soon reached. If one's auditory acuity is poor, no amount of special practice will result in a high degree of acuity. People blind from birth, despite more extensive auditory experience have, as a group, no greater sensitivity than other individuals.

In making these statements, two sources of confusion should be avoided. The one is the case of defects of the accessory apparatus of the sense organ, in the lens or muscles of the eye, for example, which may be remedied or corrected, thereby improving the function of the organ without actually changing the sensitivity of the receiving cells. The other is the fact that practice by the blind, for example, may result in very great ability to interpret sounds which the normal individual would disregard. The blind, by attending to the echoes from their footsteps, may detect the presence of obstacles or doorways in a room, but this sort of learning does not imply an increase in sensitivity of the sense organ.

Functions of the Reacting Mechanisms.—The functions of the reacting mechanisms, like those of the receiving mechanisms, show typical rates and limits of growth. Concerning the development of the glands, very little is known. Most of them seem to be functioning actively from birth until death; for example, the

thyroid, the pituitary, the adrenals, the pancreas, the salivary, sweat, oil, and lachrymal glands. The pineal and thymus appear to function actively in childhood and to die with it. The sex glands show various stages of growth, with the appearance of new functions at pubescence. Extraordinary conditions, disease, shock, overwork, may disturb the functioning and growth of any of the glands, but normally the development is determined from within.

The speed of muscular reaction, as determined by the number of taps made in a given time, or by the time, in thousandths of a second, required to jerk the hand from a telegraph key at a signal; the precision and steadiness with which a subject can move a short pointer down a continuously narrowing groove, and the strength of muscular reaction, represent fairly elementary muscular capacities upon which, among other things, the acquisition of skill depends. As children become older, their efficiency in all of these functions increases. That innate growth is responsible in a goodly measure for this development can be shown by an experiment. If we take a group of adults or children of the same age and give them five minutes' daily practice in tapping, they will have reached their limit of improvement in from 12 to 22 days. But their maximal abilities are very different. These differences, since practice up to the limit of the individuals' capacities does not obliterate them, must be innate. Young children who have reached their practice level may, after an interval of time during which growth occurs, again improve somewhat by practice. The degree of absolute achievement at any stage may be increased by special practice or experience but only within certain limits, which are determined by native endowment. When practice and other circumstances of life are equal-

ized, differences between individuals will still exist and these differences are native.

Capacities of the Nervous System.—Modifiability and retentiveness of the neurones, upon which learning depends, can be measured at least roughly by tests of general intelligence or general mental ability, or of the rate and permanence with which various types of information and skill may be acquired at different ages. As we shall see later, the capacity to learn and retain develops gradually from birth to maturity in a manner which resembles strikingly the growth curve for height.[1] While we are still in doubt about the earliest and latest stages, and other characteristics of the growth of these capacities, the essential fact that they do grow in a manner determined by native endowment is well established. The capacity to learn and retain, to profit by practice and experience, is native. Like other innate traits, a favorable environment is required to permit normal development, which may be retarded or inhibited by extraordinary misfortunes, but so far as we know, no special type of exercise or training will greatly increase these capacities. To be well fed, healthy, and normally active, physically and mentally, is sufficient to enable these powers to attain their full fruition.

Capacity and Achievement.—At this point, a very important distinction may be drawn between capacity and achievement; between growth and accomplishment. Children of the same age will, on the basis of endowment, possess different aptitudes. But aptitude does not insure achievement. What is done with one's capacity, whether it be high, medium or low, depends on how persistently, how vigorously, and in what directions it is applied. With the same ability for acquiring skills of finger and hand,

[1] See page 431.

one person may learn to write, typewrite, play the piano, draw, repair various machines, and so on, whereas another with equal capacity may acquire none of these acts of skill. With equal mental capacity, one may learn reading, spelling, arithmetic, history, and other informational subjects, while another may acquire but little in these fields. One does acquire various "tricks of the trade" as well as information and skill, but native modifiability and retentiveness are not changed perceptibly except insofar as they grow of themselves.

Growth of Behavior

Native Activities of the Infant.—We have spoken of the development of certain bodily organs and traits and of certain important capacities and functions. We find in addition to these traits and capacities, but depending upon them, a wide variety of activities going on immediately after birth. Such complex activities as those involved in the regulation of bodily temperature, breathing, circulation of blood, digestion, and assimilation, are functioning. Likewise very complicated emotions, such as fear, when a loud noise is made or when the infant is suddenly jerked; anger, when the nose, arms or other members are held; or pleasure, when the baby is rocked or rubbed, may appear almost immediately after birth. The infant may suck, sneeze, hiccough, yawn, cry, grasp objects, wave the arms, move, stretch or kick the legs within the first hour. In a few days rather well defined defense reactions occur. If you grasp the child's toes, he will attempt to pull loose; grasp his left knee, the right foot will be pushed against the hand. Most of these activities are exceedingly complicated, so complicated as to exclude all possibility of learning under the conditions

preceding birth. There is no way to account for these activities in the infant except to assume that they are the result of inner growth. Such activities are therefore termed *native, unlearned, innate* or *instinctive.*

Native Activities appearing Later.—Anatomical traits and certain capacities, we found, continued to develop after birth, and there was reason to believe that such growth was largely due to the maturing of innate traits. Some of the bodily organs, the teeth, for example, do not appear until some time after birth. It is not improbable that *activities* which appear late, as well as the growth and changes in the responses present at the time of birth, are really native.

Certain acts, such as walking, cannot function until the muscles and bones have reached a certain maturity. But neural connections as well as bones and muscles must be ready for action before a venture brings success. Apparently a tremendous number of neural connections develop innately. As there exist in the germ cells determiners of the bodily organs, so there exist determiners for neural connections. The neural organizations, like muscles or bones, are not necessarily completely developed at birth, but attain working order at various later dates. The child may attempt walking before the inner development is entirely adequate to the task with much staggering and falling as a result. But where inner growth is gradual, as it probably invariably is, imperfection of the activities in the early stages is to be expected.

How Acquired Acts may be Distinguished from Native

As the child grows older, he is observed to climb, fight, collect objects, join gangs, attempt to dominate others,

and to show an interest in the opposite sex. How are we to determine whether these traits are inborn or acquired?

Activities which appear without Opportunity to Learn.—Whether an activity is largely native or largely learned can be determined finally only by experiment. *If an activity appears when the opportunity for learning is withheld, it is instinctive.* Where it is possible to conduct such an experiment, the results should be conclusive. Very few investigations of this sort have been conducted, and all of these have been performed on animals. Spalding took some newly hatched birds, locked up each of them in a box so small that they were unable even to stretch their wings, and isolated them so that they could not observe other birds in flight. Thus they were deprived of all opportunity to learn until other birds, hatched at the same time, had become competent performers. Then they were released. They were able to fly at once, almost but not quite as well as the birds which had not been imprisoned. Their control was not quite so good; their alighting for a time was clumsy; but a large part of the ability to fly had developed without specific practice.

It seems likely that for the human infant walking is native in a similar fashion. The only way to determine with certainty is to perform analogous experiments, which for obvious reasons has not been done. In two or three instances on record, infants, who for one reason or another were given no practice in walking until well past the usual age, were able to walk very well on their first attempts.

Universality as a Criterion.—In the absence of crucial experimentation we must rely on less valid methods of distinguishing native from learned behavior. Observations of children whose life history is carefully recorded

have been one source of information. The study of primitive people, present or past, whose environment and training differ widely, affords an opportunity to inventory traits that are common to all and therefore probably native. *When a trait is found universally among members of the same species, whatever their environment or training, the assumption is that it is native unless evidence to the contrary is produced. This is the criterion of universality.* It must always be used cautiously because of the likelihood that some form of universal training may be responsible for the trait. All people may eat with some utensil but it is a trying task to teach the infant to use his spoon. On the other hand some traits, even if instinctive, may fail to appear universally because no environmental incentive is provided, or because the activity is generally forbidden. If climbing trees were instinctive, it might fail to show itself in city children; if hunting and killing animals were instinctive, it might fail to show itself universally because it is tabooed by society. The criterion of universality, while not always conclusive, is usually suggestive affording at least a preliminary test.

The Evolution of Behavior from Animals.—The study of animal behavior has been fruitful of suggestions concerning the nature of human behavior. The criterion of universality and the experimental method are both applied here more effectively than to man, and when once native traits are ascertained, it is most profitable to work out their evolution. Just as the human eye has a long evolutionary history, going back to the simple pigmented cells of the jellyfish, so forms of behavior, such as "withdrawing reactions," have evolved from lower organisms. Most profitable, of course, is the study of the higher forms of animals, our ape-like and other simian ancestry. The task of distinguishing native from acquired traits is

simplified in the study of animals because their capacity to learn is appreciably less; their behavior retains a larger proportion of the instinctive, although their inheritance of native traits is less extensive than ours. The human infant, from the time of birth, begins to learn, and this capacity increases so rapidly and is so effectively utilized, that shortly most forms of behavior which we can observe are a mixture of native and acquired elements that are difficult to disentangle. There is, however, pretty fair agreement among the experts concerning several native tendencies.

The Varieties of Instinctive Activities

Instinctive activities vary greatly in complexity. At the one extreme are relatively simple responses, such as winking when a particle strikes the cornea of the eye, the jerking of the finger when pricked, swallowing, sneezing, grasping, yawning, coughing, each to the proper stimulus. These are usually called *reflexes,* but they are not to be sharply contrasted with feeding, walking, crying, or fighting, which are usually called *instincts.* There is a continuous gradation from the most simple to the most complex; the term, reflex, is applied to the activities at the former, instinct, to those at the latter end of the scale.

Instinctive activities differ also in the firmness of their organization; some of them persist throughout life with little modification; some of them may be, at least in their external form, readily changed. Taken as a whole, the simpler ones, the reflexes, are hard to modify and almost impossible to eradicate entirely. For example, the "knee jerk" and the "pupillary reflex" are so constant that their absence is indicative of serious bodily disorders. Nearly all of the vital activities—heart action or

digestion—cannot be greatly or permanently modified by conscious effort. Such activities as smiling, laughing, walking, talking, are more readily changed. The various speech organs, including the nerve connections, are natively organized in such a way that various sounds can be produced. Out of these elementary sounds, after many trials, patterns are acquired which result in spoken words. Learning consists in the reorganization of native units into new patterns of response, as when one learns to speak English, French or Chinese words. In this sense, vocalization is modifiable. The same is true of manipulation. At birth, or shortly after, a number of fairly well established native reactions appear. The child grasps a rod placed in his palm in a particular way; in fact, his reaction is so well developed that he can sustain his whole weight with his grip. Tickle the palm of his hand, pinch his finger at various places, rub his thumb, different reactions will occur. What we find is a large number of specific reactions to specific stimuli that are fairly constant and persistent. But give the child a rattle, a string or a spoon, and shortly he will acquire new tricks of manipulation; tricks that represent merely new patterns or arrangements of the elementary native responses. The minute elements of response are not readily changed, but they are readily reorganized into new, acquired patterns.

The Characteristics of Instinctive Activities

Such units as manipulation and vocalization are often called instinctive tendencies to react, the reactions themselves varying with the circumstances and falling into new patterns through learning. Most of the complex native behavior to which the term instinct is applied is

of this sort. Given the proper stimulus, the instinctive tendency is aroused. Once aroused, the tendency may persist for some time, showing itself in an impulse or readiness to act, to carry through a reaction which affords a satisfying relief. These facts will be clarified by an illustration.

The feeding instinct which has been studied recently in animals, infants and adults, portrays several important features of complex instinctive behavior. Certain bodily conditions, of which one invariable symptom is the vigorous contraction of the walls of the upper part of the stomach, are the usual stimuli which arouse the state termed *hunger*. Hunger is clearly impulsive; it is a state of readiness for certain activities, namely, the eating of food; it is a *preparatory reaction*. As soon as the hunger contractions come on, the subject becomes restless. Infants begin to squirm in their crib, and shortly to cry. Adults, engaged in sedentary work, are likely to arise and move about; if asleep, they may twist and turn, sometimes waking. Muscular strength and mental alertness tested during hunger is found to be somewhat greater than during stomach quiescence. The salivary gland and possibly others show an increased secretion. These are preparatory reactions, accompanied by an impulse to get at food. If the end reaction, the eating, is long delayed, the condition is reported as distinctly unpleasant—witness any man's behavior when dinner is late. Animals and infants will become violent under sharp hunger. To consummate the ends to which the native impulsion leads, is, on the contrary, highly satisfying and in the case of adults, we may say also pleasant.

The Impulsive Character of Instincts.—In this description of hunger, an important characteristic of the complex instinct is disclosed, namely, its dynamic or im-

pulsive character. At first some stimulus, such as the bodily condition antecedent to hunger, activates a state of readiness, which, in the case of the food-getting instinct, embraces contraction of muscles in the stomach, tenseness of certain skeletal muscles, activity of the salivary glands, and probably other preparatory reactions. Among human subjects, this state of readiness is experienced consciously as an impulse; an impulse to secure and eat food. If food is not available, the state of readiness and the impulse (at least in man when awake) may persist, disclosing itself consciously in many ways, such as in ideas of food or eating, or of how or when food may be procured, and objectively by restlessness or moving about. If the subject is asleep, we can be less certain about the conscious impulses, but the state of readiness is shown by devices that record contractions of the stomach, and tossing, twisting or other movements of the body. The bodily state of readiness and the conscious impulses are typical of all complex instincts. They are directed toward some *consummatory reaction* or series of reactions.

Instincts Important Factors in Human Dynamics.—Stimuli, whether they arise in some external situation or in some inner condition of the body, arouse tendencies or drives to activity simply because original nature is what it is. A man wants to rest, to eat, to sleep, to be praised, to be looked at approvingly, or to add new items to his collection of stamps or pictures, fundamentally because he is by nature so organized. Instincts, then, provide a large number of the determining or dynamic forces in behavior. They account for forms of readiness to act, or in less technical terms, for many particular drives, motives, desires, inclinations, urges. To understand the instinctive equipment of man is to comprehend the direction in which activity is likely to run, to perceive, in some meas-

ure, what kinds of activity individuals are likely to seek and avoid.

Every instinct provides states of readiness for, or drives to action; but are all motives and impulsions instinctive? Here we find differences of opinion. One authority, McDougall, answers the question as follows: "We may say, then, that directly or indirectly the instincts are the prime movers of all human activity; by the impulsive force of some instinct (or some habit derived from an instinct), every train of thought, however cold and passionless it may seem, is borne along toward its end and every bodily activity is initiated or sustained. . . . Take away these instinctive dispositions with their powerful impulses, the organism would become incapable of activity of any kind; it would lie inert and motionless like a wonderful clockwork whose mainspring had been removed or a steam engine whose fires had been drawn."

Habits as "Drives" to Action.—Other authorities are inclined to believe that McDougall's statement is somewhat extreme. They believe that habits, that is, acquired activities, should be placed with instincts as dynamic factors in determining human conduct. McDougall admits that habits *derived from instincts* are motive factors, but others are disposed to believe that there are habits, possessing driving potency, which are really not derived from instincts.

Consider a man who has for many years smoked a cigar after dinner. When the meal is over, the organism gets into a state of readiness for the smoke. If the supply of cigars is exhausted, the state of annoyance is usually evident. The impulse may become very strong. The victim becomes restless and may jam on his hat to walk several blocks to the cigar store in order, as we say, to

"satisfy his habit." So with other types of acquired activities—the paper at breakfast, the afternoon nap, tea or a game of tennis, the Saturday evening trip to the movies—once they are habituated, the proper setting arouses them to readiness. These activities, of course, are not instinctive, although as McDougall says, they may be at least indirectly related to native tendencies and in a measure derived from them.

Many habits certainly are formed in the service of, or to satisfy, the instinctive tendencies. The important thing about the eating instinct, for example, is not that one instinctively eats in such and such a way, but the fact that the hunger impulses persist throughout life and that they are the motives behind untold number and varieties of human activity. Men will go to great extremes of activity under the drive of hunger, and the lives of all of us are influenced by the food-getting instinct, subtly effective even when not acute.

Instinctive Tendencies guide Habit Formation.—The sex instincts, self-assertion, collecting and hoarding, and many others to be enumerated in the next chapter, also act as "drives" like hunger, although differences in strength are admitted. Altogether, they form the fundamental dynamic forces which guide human conduct. When we buy a hat, take up dancing, study grammar, answer a personal question, decide on an evening of work or leisure, choose a friend, vocation, or mate, the subtle urges of original nature are effective motives even if they are quite concealed and often not intelligible either to ourselves or others. When all of the facts are known, it is quite probable that native tendencies will be found involved in some degree in all acquired reactions or habits, although frequently the relation may be distant and indirect.

The Permanence of Instinctive Tendencies

It has frequently been urged that instinctive tendencies are of unstable character, subject to sudden transformation or disappearance. It has been assumed that childhood is divided into sharply defined periods or ages—the age of fear, of timidity, of physical activity, of anger and fighting, of collecting and hoarding, of gang activities, of mating tendencies. While it is true that certain tendencies do vary in strength and insistence from time to time, this picture of the transitoriness of instincts is usually overdrawn. The main fact about most native tendencies is their essential permanence and stability. Each has its course of growth, its maturity and eventual decay, but in the main, development is gradual and maturity is of long duration.

The efficiency of muscles, the capacities of sense organs, the retentiveness of nervous structure we found to be present in some form at birth, to develop gradually, although at different rates, and to reach, early or late, a maturity at which they remained until old age. Tendencies to manipulate, to fear, to be angry, or to fight, may likewise be observed at birth, or shortly thereafter. They are subject to growth until a maximum is reached, sometimes very early as in the case of fighting, or late, as in the case of the mating instinct. Pubescence, like the sudden boiling of water which has been a long time heating, is actually the culmination of a long period of growth. Just as the sensitivity of the sense organs matures early, and the ossification of bones late, different instinctive tendencies complete their growth at different times, but few appear or disappear suddenly.

While the essential native tendencies are stable, the potency of the particular stimulating situations may

change. The tendency to become angry and to fight appears early and lasts long, but the kinds of things which make us angry may vary from year to year. The native tendency to collect and hoard appears in infancy and persists throughout life, although at five, we may collect colored cards or dolls, at ten, stamps and cigar tags, at fifteen, marbles, tops and baseball bats, at thirty, rugs and furniture, and at fifty, books and paintings. The native tendency to seek social approval is permanent, although the kind of approval sought, the way in which we seek it, and the sort of people from whom it gives most satisfaction, may change greatly from time to time.

The Evolution of Original Nature

Instincts and other native traits are stable in another sense. Modern biology tells us that the original nature of the human race changes very slowly, that the native equipment of mankind today is not appreciably different from what it was thousands of years ago. Races living long before the birth of Christ are believed to have had about the same bodily organs, the same physical capacities, the same instincts, emotions, and intellect which their descendants now have. This is not a denial of evolution in man's equipment, but a statement of the fact that evolution is extremely slow. Our native organization, if the biologists are correct, would seem to constitute a more effective adaptation to the primitive life of the savage than to modern customs, habitations, and conditions. We would expect to be well fitted to a life of abundant physical activity in the search of foods, berries, nuts, game, or in conflict with animals and other enemies, to the avoidance of such dangers as lightning, animals

prowling in the darkness, winds, floods, falling trees or rocks, to rude sorts of implements or houses, to fairly simple social groups, rather than to typewriters and printed books, to refined foods and confined quarters, to indoor vocations and complex social conditions.

The Imperfections of Original Nature.—To the probable fact that original nature is imperfectly adapted to our environment, special emphasis should be given, because in popular belief and in not a few books on pedagogy the doctrine of nature's infallibility has been upheld. It is asserted that all instincts *must* have some utility, perhaps not always perceptible to man. Instincts, it is said, exist to perpetuate the individual or the race, and in particular they serve to avoid danger, secure food, and so on. All of this is true only in a general way. On the whole, instinctive capacities do have a utility, particularly under more primitive conditions of life, but the exceptional instances are many and important. Our native equipment provides only a rough adjustment to the environment; just good enough, so that with the assistance of the capacity to learn, the species as a whole manages to survive. That many species have not survived and that those that have, still experience difficulties in adjustment, are proof enough of the fallibility of our inherited equipment.

QUESTIONS AND EXERCISES

1. Make a brief topical outline of the chapter to be used as a guide in attempting to recall the more detailed but important facts.

2. Rank the various criteria of *nativeness* in the order of importance.

3. List a number of traits that are universal but probably learned and a number which are universal but probably instinctive.

4. Which of these are mainly *learned*, which mainly *unlearned?*

Situation	*Response*
A. Irritation in nose	Sneezing
B. Sight of food	Hunger
C. Being crowded	Anger or irritation
D. Sight of a gun	Fear
E. Fireworks	Estimate cost
F. Printed words	Move eyes over them from left to right
G. Sight of approaching auto	Turn to right

5. Which of these words and phrases are applicable to a description of original capacities; good, bad, present at birth, infallible, unavoidable, possessed by all men, a handicap, starting point of education, persistent till death, unchangeable, blind, Nature's gift, inherited?

6. Define reflex, instinct, instinctive activity, instinctive capacity, inborn capacity, instinctive tendency.

7. Put in the proper words: 1. The muscle has the..........to contract. 2. Caruso had an.......... ....for music. 3. The cat has an..........to hunt mice.

8. In what sense may an instinct be described as "mechanical"? What objections are there (if any) to describing instinctive activities as machine-like operations.

9. Is a child to be held responsible for unmoral acts prompted by native impulsions?

10. Are instincts decidedly transitory? Compare a child of eight with an adult of twenty-eight.

11. What differences in educational practice would follow upon absolute proof, (a) that instincts are transitory, and (b) that they are permanent?

12. Is there any reason to believe that some instincts are not present at birth? That those which are present at birth are fully matured? That there should be any relation between the growth of some instincts and the development of sensory, motor or glandular mechanisms?

13. Would you favor dividing childhood into a number of "ages," e.g., the ages of memory, of imagination, of collecting, etc.?

14. Do you know of any bodily organs that are useless or even a disadvantage? What traits of human behavior are similarly of little use or probably a handicap?

15. Compare both the native equipment and the environment of man today, with those of men living 20,000 years ago.

16. Name some acquired tendencies or habits which seem to be as strong as instinctive impulsions.

17. Trace as accurately as possible the growth of the collecting and hoarding tendencies from infancy to old age.

REFERENCES

William James, *Principles of Psychology,* 1890, vol. II, chap. 24, is an interesting and historically significant discussion of instincts.

William McDougall, in his *Social Psychology,* 1908, and R. S. Woodworth, in his *Dynamic Psychology,* 1918, discuss the relative influence of native and acquired "drives" in everyday life.

John Watson, in his *Behavior: An Introduction to Comparative Psychology,* 1921, Chapters 4 and 5, discusses the evidence bearing on the native equipment of animals.

E. L. Thorndike, in his *Educational Psychology,* 1913, vol. I, "The Original Nature of Man," gives the most complete discussion of the nature of instinctive tendencies.

The study of hunger to which reference is made in the text is described by Tomi Wada in *An Experimental Study of Hunger in Its Relation to Activity,* Archives of Psychology, No. 57. 1922.

CHAPTER VII

AN INVENTORY OF INSTINCTIVE IMPULSES AND ACTIVITIES

To many stimuli which the world provides, unlearned or instinctive reactions are made. The stimulus may originate in the body itself, as in hunger or thirst, or outside the body, as when fear is aroused by a clap of thunder. The response may be immediate, as when one dodges a flying object or grasps an apple, or it may be delayed, as when a hungry individual searches for food or chases prey. When the final response is delayed, preparatory reactions are set up which constitute states of readiness for further consummatory reactions. Consciously, the human adult, at least, is aware of impulses directed toward the consummatory responses—of conscious urges to further action. In the descriptions of human instincts we should consider then: (1) the stimuli or stimulating situations; (2) the preparatory reactions and conscious impulses; and (3) the final or consummatory reactions.

The term *instinct* is applied to various units of native behavior that are singled out for discussion. These units are seldom precise; most of them include a number of elements which may be found in several instincts. For example, if we speak of physical activity as an instinct, we would include under it manipulation, walking, vocalization, and many other reactions. If we speak of the smaller unit, manipulation, as an instinct, we would in-

clude various activities that others might place under grasping, food getting, collecting and hoarding; and each of these could be subdivided into hundreds of more definite impulses and reactions called forth by particular objects. The last procedure, stating in detail the stimulus, the impulse, and the response, is the ideal, but is impossible because of the paucity of information. What we must do is to break up instinctive behavior into units that can be conveniently handled in the space at our disposal. These units will be called instincts, and to each a name will be given. It is important to remember, however, that each so-called instinct—feeding, collecting, or fighting—is not an independent, discrete, invariable entity or power, but merely an aggregate of specific impulses and reactions to specific stimuli, with a ragged and changing boundary.

Classification of Instincts

What criteria shall we use to select the units and names? A common method is to give a name to the *purpose* that a group of these specific tendencies to act seems to serve, such as the instinct of self-preservation or the instinct of reproduction. This is a poor method, not only because such instincts are too broad to be useful units for thought, but also because, by implication, the constituent activities are assumed to have a definite purpose or utility. The effort to name instincts by the situations which arouse them or the responses which the organism makes presents difficulties because of the complexity of both situations and responses. Perhaps the simplest way is to indicate by some name the impulse which arises, but the trouble here is that in the case of reactions that are seldom delayed or interfered with—the condition which makes the impulse more appreciable—

no terms now in use are available. Hunger is the name of the impulse for feeding, thirst for drinking; these are commonly experienced. But there is no special term for air getting—which is seldom thwarted—unless we call it the air getting impulse or the impulse to breathe.

In the inventory which follows the names apply mainly to the impulse or the reactions, or both, and the instincts will be grouped mainly according to the types of stimuli which arouse them, as follows:

1. Instinctive responses to bodily or organic conditions.
2. Instinctive responses to objects or events in the environment.
3. Instinctive responses to the presence or activities of other human beings.

The inventory will be followed by discussions of the relation of original tendencies to mental activities, and to satisfying and annoying states of affairs.

Instinctive Responses to Bodily or Organic Conditions

In this group may be included a very large number of complex impulses and reactions which are studied primarily by the physiologist, but whose influence upon human conduct is very important. Among them may be mentioned the following:

Eating
Drinking
Breathing
Resting
Sleeping
Voiding
Getting cool when too warm
Getting warm when too cool

In most of these tendencies, the exact nature of the organic condition which is the stimulus is only imperfectly known, but the impulses, even if unnamed, are understood by every one from personal experience. The impulses to secure food, water, air, rest or sleep, left unsatisfied, are tremendously potent determiners of conduct. Under acute hunger, thirst, or suffocation, activity for relief may become violent. The traveler lost in the snow or the unrelieved soldier may give way to the impulse to sleep even if death is the probable result. Modern life, to secure comfort and uniformity of behavior, makes provision, when it may, for abundant and regular relief of the organic impulses. We find little of importance for our purpose in the forms of native overt reaction which characterizes the fulfillment of these impulses. There are unlearned ways of picking up, carrying to the mouth, sucking, or chewing; ways which vary according to the size, shape, or consistency of the food, object, or the position of the body; native ways of spitting or letting drool out, of expressing satiety, most of which may be greatly modified through experience or instruction, whereas swallowing, digestion, waste elimination, breathing, and other activities, along with the impulses, cannot be readily or permanently altered by deliberate learning.

Instinctive Responses to Objects or Events in the Environment

The important instinctive tendencies aroused primarily by external objects or conditions, other than human beings, are listed below.

Gross bodily activities, such as walking and climbing
Manipulation
Vocalization—weeping, laughing

Avoiding reactions
Overcoming obstructions
Mastery
Fighting
Submission
Collecting and hoarding

Gross Bodily Activity.—An infant, when awake, is almost ceaselessly active; arms, legs, head and trunk are moved by contraction of the large bodily muscles. The stimuli are not easy to discover, but it is probable that the bodily position, external pressures, things observed and possibly heard are involved. Without doubt, internal stimulation, hunger, visceral discomfort, fatigue, and other conditions have an influence as well. Though the stimuli are too complex to unravel, we can be fairly sure that the child is making just the reactions he does, because just such and such stimulations are affecting him. A constant stream of stimuli provokes a continuous series of reactions.

The impulses to be physically active are quite as real and dynamically of the same order as the impulses to secure air, food, or sleep. The demand for bodily action probably increases with the maturing of muscles, bones, and nerve connections. It is very pronounced from four to six, hence the newer kindergarten and primary school practice makes wise provision for it, often without sacrifice of other things, since arithmetic, reading and spelling may be introduced, in part, through active games. The impulses become no fewer or less intense as the child matures. Gross bodily efficiency, however, wanes relatively early. The professional boxer or baseball player reaches his "peak" in the early twenties, at thirty he is considered "old," and few remain in the first ranks at thirty-five.

Of the important forms of organized bodily activity,

which are native and which are acquired? Walking, we found reason to believe, is native, although practice modifies and perfects it. Other forms of maintaining equilibrium when standing or moving, as in stooping, turning, running and jumping, are largely native, and climbing is said by many to be native. In swimming there is much to learn; the desire to swim, as well as the ability, seems to be acquired.

Manipulation.—The impulse to manipulate objects appears soon after birth. The hands of the school child simply itch to fumble with anything about him. He twists and turns it, rubs, thumps, pulls, tears, rattles, drops, throws. The impulses, especially when the child is seated in school, are irresistible.

While the human hand is an extremely adaptable instrument, capable of a multitude of performances, it has native limitations both of structure and neural organization. Place the palm flat on the table and compare the motility of the first with that of the third finger. The superiority of the first is doubtless largely native. In determining the optimum method of holding and moving a pencil in writing, the innate aptitudes of the various members should be the starting point. The difficulty of acquiring particular abilities—writing, handling tools, playing a piano—depends, mainly, upon the degree to which such activities demand the reorganization of native reactions.

It is often said that manipulation is one form of curiosity, of exploration and inventiveness. While it is true that the hand, like the eye or nose or ear, may be the means by which other native impulses seek expression, manipulation may be said to exist for its own sake. Just to manipulate—witness the infant or the imbecile—is instinctively satisfying.

Vocalization.—All that has been said about manipulation could be repeated for vocalization, with the change only of the names of organs and responses. There are native impulses to vocalize, and just to make vocal responses is satisfying. One investigator found that a child at the age of six averages more than a thousand articulate sounds—words or exclamations—per hour. On entering certain schools, vocal expressions are suddenly curtailed to about forty per hour. While it is probably seldom true that nervousness, stuttering, embarrassment at speaking in the midst of a group, and other difficulties, are the results of such inhibitions of vocalization, wiser practice employs a tapering off form of adjustment to school conditions and enlists oral speech, as well as physical action and manipulation, in the service of the school subjects.

At birth the infant has a single instinctive cry, to which are shortly added several distinct forms characteristic of hunger, pain, and anger. Before long, there appear various forms of cooing, gurgling and babbling sounds, out of which by reorganization and combination, speech, song, and other vocal expression appear.

Imagine a boy reared in isolation by a dumb guardian. What would be the character of his vocalization? There would be certain changes in power and tone with growth; the breaking voice in adolescence would mark the development of the heavier tones of manhood. There would be a number of instinctive cries, the cry of sudden pain, of rage, of hunger, of helplessness, of surprise, and some form of laughing; but probably everything else would be learned and patterned after sounds heard in the environment. The cries of animals and birds, the groaning of trees, the moaning of winds, would be taken as models of which imitations would be made; some of

them readily, some with difficulty. A bright boy would probably develop quite a number of shouts, cries, mutterings or songlike vocalizations, just for the satisfaction that developing original combinations of sounds would afford.

Two forms of instinctive vocalization, *weeping* and *laughing,* deserve special mention; and of these the former is better understood. Weeping is a common instinctive response in helplessness. Its utility, especially in infancy, is clear: it may bring relief. It is early discouraged; at least, the child is told that it is unmanly to weep, that is, to admit helplessness. But even adults when suffering injury, illness or disappointment concerning which they can do little or nothing, experience the impulse to weep, although they may not actually break into tears.

Many hundreds of pages have been written in efforts to explain the function of, and stimulus to, laughing, but no single formula is adequate. One thing is certain; general well-being predisposes to laughter. Healthy infants and many adults burst into laughter for almost no reason at all. Notable, too, is the fact that we seldom laugh when we ourselves are injured, ridiculed, or in any way discomfited—when the joke is on us. A suddenly discerned evidence of our own power or superiority, as by outwitting a rival, observing another's chagrin or embarrassment, or by perceiving our own quick wit in seeing through a joke, usually provokes laughter. This would link mirth with *mastery,* a strong native impulse, as we shall see later.

Avoiding Reactions.—Under this heading may be included a number of native responses such as jerking away a member of the body which has been stung, bitten, scratched, burned or otherwise hurt; winking, spitting,

sneezing, coughing and vomiting—responses made to irritations of one sort or another. Dodging, throwing up the arms, shrinking, cowering, hiding, standing stockstill, and fleeing are instinctive responses to certain things seen or heard, particularly to large or strange objects or events, such as a beast, a rolling stone, thunder and lightning. The emotion of fear, which will be discussed more fully in the next chapter, is often experienced in response to such situations.

Overcoming Obstruction.—It is characteristic of children and adults to desire to go about their play or work without interference. To any kind of obstruction the native reaction is the arousal of an impulse, usually coupled with vigorous activity, directed toward the removal of the obstacle. A child's toy which will not work, a door which will not open, a block of wood which will not split, a thicket which will not permit passage—all such impediments provoke instinctive impulses and acts to overcome them. So commands and restrictions, in so far as they interfere with activities under way, tend to arouse resistance. There is, then, at least one native tendency that operates in opposition to the development of "habits of obedience."

The tendency to overcome obstruction and interference was shown in an interesting way in a laboratory experiment, in which a subject engaged in the task of typewriting was subjected to a number of distractions, such as the sounds of buzzers and bells, or sudden changes in illumination. He was at once aroused to overcome such interferences. His pulse ran up, his brow was wrinkled, teeth were clenched, the keys were pounded harder than usual, and in most instances the typing was kept up to the average, although more energy than usual was consumed.

Mastery or Self-Assertion.—The child attempts to overcome obstruction, interference and domination, but this is not all; he seeks positively to dominate people and things, a tendency which is native. He likes his blocks to stay put, his horn to blow, his dog to come when called, his playmates to follow orders. Adults have the same impulse to be master of the situation. To climb a tall tree or to chop one down, to breast a strong current, to "break" a spirited horse, to lift a huge weight, to down an opponent in wrestling, to swing a big deal or boss a crew of men, are forms of gratification of the impulse to mastery. To succeed in any such undertaking is satisfying quite apart from prizes, social approval, or any other form of reward.

Fighting.—The tendency to overcome obstructions to, or interference with, an activity under way is a close kin of the impulse actively to seek domination, and both are related to pugnacity. Think of a boy building a playhouse. If all goes well, each nail driven and each board affixed satisfies his impulse of mastery, and the thought of the completed house is a stimulus to his self-assertion. Let some of the boards split or some of the nails bend, and the boy is aroused to overcome these obstructions to progress. If things go from bad to worse, swelling rage may lead to a fighting attack in which the structure is utterly demolished. Or, with things going well enough, if another boy interferes by word or deed, disregarding commands to desist, he may be the object of attack. The stimulus to fighting is an interference with an activity under way. The pugnacious attack is simply the most violent form of the effort to overcome an obstruction in the path of one's action, and inasmuch as it is the last resort, it is a less frequent reaction.

Is fighting engaged in for its own sake? It would seem

to be among dogs, cats and other animals. An investigator who followed the activities of boys' gangs found individual "free for all" and inter-gang fights to be almost universal. Of course, fighting is generally discouraged and punished, although we still need jails for offenders. Although instinctive rough and tumble attack is usually brought under control, the pugnacious impulse persists. Instead of with tooth and nail, we may learn to attack with cutting remarks, piercing looks, or with annihilating thoughts only, but in these acts the pugnacious tendency is revealed even among the most sophisticated adults.

Submission.—Submission is the antithesis of the tendencies to overcome opposition, to secure mastery and to fight. Forced submission to an obstinate obstruction or to a superior opponent is common enough, but it is not an instinctive satisfier. It is characterized by such behavior as weeping, anger, chagrin, envy, jealousy, shame or embarrassment. Frequently, however, there appears an impulse to submit when submission seems to be instinctively satisfying. The situation which provokes submission is one which obviously cannot be mastered. Thus the child may be submissive to the adult, the adult to a wiser or more influential person, or to society as a whole. Admiration, awe, reverence, veneration, "hero worship," are indicative of willing submission. Universal tendencies to be awed by, as well as to venerate and idolize unusual, unintelligible or powerful natural phenomena, such as winds, thunder, or the sun, perhaps are rooted in submission as well as in fear.

Collecting and Hoarding.—The child tends to approach objects which attract his attention, pick them up, manipulate them and carry them away. There is more here than mere desire for sensory satisfaction and manipulation; there is a native impulse to collect and hoard

for its own sake. The boy collects cigar bands, stamps, picture cards, and other trifles, as may be observed in the advertisements of papers or magazines for young people. While the type of materials collected changes with age, the impulse persists. However useless our collections may be, mere possession is satisfying; however huge, we covet more, because the impulse to collect and store away is rarely satiated.

Instinctive Responses to the Presence and Activities of Other Human Beings

The tendencies to be listed under this heading are often called *social instincts,* because of their intimate relation to the organization of social institutions. We have just described certain tendencies, such as those to overcome obstruction, to secure mastery, to fight, and to submit, which may have as their stimulus the presence and activities of human beings as well as other objects and events. The dividing lines between the three groups of instincts are obviously not sharp. In mastery, submission, fighting, and markedly in mating tendencies, organic conditions, as well as percepts of external situations, are involved in activating the states of readiness for the consummatory reactions.

In this group of more specifically social tendencies, the following will be mentioned:

Parental behavior
Mating behavior
Gregariousness
Desire for social approval; avoidance of scorn

Parental Behavior.—Most animal species show definite forms of parental behavior; among mammals, the mother most clearly. The sow with its litter, the hen with its

brood are familiar examples. In these cases the elaborate mothering tendencies are mainly unlearned, and most authorities believe that the maternal impulses of humans are equally native.

The normal stimulus is the helpless infant, although the organic condition of the mother for a time following childbirth doubtless sharpens the instinctive appeal. At any time, however, the presence of an infant tends to produce smiling, patting, and other kindly behavior. To the child's every act, its coos and gurgles, smiles, cries of pain, fear or hunger, ready responses are made. The spontaneity of the protective reactions of parents for offspring have been noted and lauded for many species. Among human mothers, few impulses are capable of producing equal sacrifices.

The impulse to protect and comfort the young becomes readily attached to other people, animals, or objects, particularly the helpless or suffering, and so it becomes a motive for general good will. Societies for the prevention of cruelty to animals, or of child labor, for the relief of suffering in foreign lands; public institutions for the homeless, crippled, blind, feebleminded, and so on, are evidences of the parental impulses.

The Mating Instinct.—The mating instinct reaches maturity relatively late, although evidences of its existence are apparent soon after birth. Organic conditions contribute to the arousal of the mating impulses, a fact made obvious by the periodic excitement of animals.

A great deal has been written of late by certain schools of pseudo-psychologists concerning the power of the mating instinct for good and evil. The statements of some that the sex instinct is the most powerful motive in human behavior is a vast exaggeration. The impulses to secure food, air, or water, would certainly be more power-

ful if denied. The thwarting of the mating impulse seems to be the main source of the difficulty with it in modern society. Delayed marriage, together with the social taboos, the insinuations of shame and indecency, provide the circumstances for an unwholesome attitude toward entirely normal, innocent, but persistent impulses. With proper understanding and guidance, the mating impulses, like others, may be properly controlled and enlisted in desirable service.

Gregariousness.—Gregarious animals, buffaloes, sheep, or wolves, are those which live in herds or flocks. In these species herding together is instinctive. Others, such as cats, tigers, or lions, are solitary beasts. The human species is essentially gregarious. The seclusive individual is occasionally found but is always regarded as abnormal.

Strictly speaking, gregariousness is merely an impulse to be with other people. When alone in an isolated place, we become uneasy and lonesome; solitary confinement is a most trying form of punishment which usually brings confession or breakdown. Impelled, as we are, to herd together, social activities and institutions are worked out. Other than the herding impulse, there are few instincts that are specifically social in character, although the mating and parental instincts have most important social consequences. To these should be added another social trait, namely, the impulse to secure social approval.

Desire for Social Approval.—The impulse to secure social approval goes beyond the mere satisfaction of being in a group. The approving words, glances, smiles or attitudes of other people are among the keenest sources of satisfaction. In numberless direct or subtle ways we seek approval; the child, by displaying his repertoire of tricks; the youth, his strength, daring and skill; the adult,

by means of personal appearance, clothes, relatives, social connections, wealth, achievement in business, politics, society. athletics, philanthropy, or by wit, generosity, humor, aloofness, and in other ways too diverse to recount. Lacking superiority in skill or valor, social virtues, personal appearance or intellectual accomplishment, one may resort to fine clothes, fine manners, fine talk, extravagance, boasting or arrogance.

As approval is a keen satisfier, so social disapproval may make life intolerable. Our sensitivity to facial blemishes or bodily disfigurement, the misery occasioned by a social blunder or a public criticism, are as intense as they are irrational. We are disturbed even if a dog or a tramp acts disapprovingly. A Zurich psychiatrist has developed a conviction that many nervous and mental disorders are the results of the continuous disapproval which physical defects or deficiencies may bring. Some people are much less susceptible than others to social scorn or disapproval, and of those who are very susceptible, but few are likely to become mentally unbalanced on that account.

In many instances, the impulses to secure social approval and avoid scorn are similar to the impulses to secure mastery and avoid domination. Both may, in fact, be operating at the same time, but there is a difference between them. One may check his self-assertive tendency to a point of submission or humility in order to be considered "nice," although here the desire for social approval is conceivably the mastering impulse in disguise. On the other hand—and here the distinction is clearer—a man may dominate his wife and family, or his school room, so severely as to bring the disapproval of all who observe, yet the hard master may enjoy the rôle. In the case of bullies on the school ground or elsewhere, the im-

pulse to self-assertion may run counter to the impulse to secure social approval.

Mental States and Activities, Native and Acquired

We are born with the sensory and nervous structures which are the organs of conscious states. Sensations such as red, cold, and sweet are experienced at birth and are therefore native, but the perceptions of things and relations—boxes, shoes, fruit, or distance, number, weight—are acquired. The basis for such acquisitions, our receiving, connecting and responding mechanisms, are of course native, but just what percepts are built up depends upon our environment and training. So with memories, ideas, beliefs, images; all are, in the same sense, acquired.

Impulses.—Impulses are both native and acquired. Every instinct has its impulses, and in general, the native impulses are more stable, less readily modified than the motor responses which go with them. The emotions of fear, anger, and joyfulness, and similar states, such as excitement, are native, since they appear at birth, and all are permanent. Lust develops later, but it is probably native. Whether sympathy, envy, jealousy and lonesomeness, elation and many others are primary, or whether they are fusions or reorganizations of those above is not known with certainty. Any emotion may come through experience to be aroused by stimuli that did not instinctively arouse it. It is native to be afraid, but not to fear an electric wire. The act of fearing is unlearned, but what we fear in many cases is the result of experience.

Mental Activity and Learning.—Manipulation, collecting and hoarding, eating, fighting, and other native activities, we found, were satisfying for their own sake, without regard to the utility or result which they might

accomplish. Mental activity, just to have sensations, for example, is likewise intrinsically satisfying. In addition to their intrinsic effects, manipulation, collecting, having sensations and other activities may be the means by which other impulses are satisfied. Among the latter is curiosity, without doubt a native trait which shows itself in a great many activities. The child likes to manipulate in general, but he likes especially to manipulate a new, at least a relatively new object. The novel arouses his curiosity, and during the course of manipulation, new percepts, ideas, and skill may be acquired. He is doing more than merely manipulating; he is exploring with his eyes, ears or other senses as the object permits. The new picture book provides for visual exploration; the music box, auditory; the flower, visual and olfactory, and the fruit, gustatory. No matter what the object may be, the child will probably apply eye, ear, hand, tongue and nose to it. In these exploratory activities, we find the beginning of the instinctive impulse to learn, to acquire information and skill. The child seeks the novel thing or situation which offers the widest opportunity for learning. Having satisfactorily mastered one device, he lays it aside for others which offer opportunity for fresh experience. To comprehend, see through, adapt oneself to new objects and situations, in a word, *to learn through experience* is a strong and, needless to say, important human tendency.

Curiosity.—While it is correct to say that curiosity is a native trait, the term does not cover the field of learning adequately. The tendency to seek the novel is one instance of the impulse to learn. To acquire skill, new percepts, to memorize, to solve problems, to reason, all of these are forms of learning and each is by original nature satisfying for its own sake. Of course, there are age and

individual preferences and circumstances which influence the impulses. The satisfaction in learning is increased by successful accomplishment, perhaps by giving play to the mastery impulse, and decreased by failure. Too much monotony, too long or too difficult tasks, and the competing impulses to eat, rest, or physical activity may be unfavorable to school learning, but it is important to realize that interest in learning is never wholly or even mainly derived from ulterior motives; it is satisfying for its own sake.

Native Satisfiers and Annoyers

Studies of human and animal behavior disclose the fact that, even shortly after birth, before the individual has had much opportunity to learn, certain states of affairs are sought, and when attained are maintained, at least for a time. Other conditions are avoided, or at least some attempt at avoidance appears. The hungry cow seeks grass and having obtained it, proceeds to eat until satiated, whereas it will disregard bread or meat. The dog, on the contrary, seems to be satisfied by meat or bread, but usually disregards grass. Ducks and geese seek water and revel in it, whereas chickens and cats are disinclined to a bath and try to escape when they are introduced to water. Dogs take readily to human companions with a devotion that cats seldom show. Lambs gambol with each other in a way that tigers seldom do. Each species has its own inclinations and disinclinations that seem to be inborn and modifiable only within limits.

The human species has its set of desires and aversions. We like dogs and cats better than snakes and toads. We take to foods which taste sweet and avoid those which taste bitter. On the whole, we prefer harmonious sounds

to harsh sounds, the odors of fresh fruit to the odors of decayed fruit, sunlight to darkness, air of moderate temperature and humidity to air extreme in these respects, soft textures next the body to harsh textures. Really, there is no very good or ultimate reason why we prefer some things or conditions to others. Our choices, in these instances, are not reasoned or intelligent, but instinctive. We were born to like some things and dislike others.

Different species differ in their attractions and aversions, or likes and dislikes, because their birthright is different. As William James says: "Why does the hen, for example, submit herself to the tedium of incubating such a fearfully uninteresting set of objects as a nestful of eggs? Why do men always lie down, when they can, on soft beds rather than on hard floors? Why do they sit round the stove on a cold day? Why, in a room, do they place themselves, ninety-nine times out of a hundred, with their faces toward its middle rather than toward the wall? Why do they prefer saddle of mutton and champagne to hard-tack and ditch-water? Why does the maiden interest the youth so that everything about her seems more important and significant than anything else in the world? Nothing more can be said than that these are human ways, and that every creature likes its own ways, and takes to them as a matter of course . . . it is not for the sake of their utility that they are followed, but because at the moment of following them we feel that that is the only appropriate and natural thing to do . . . to the animal which obeys it, every impulse and every step of every instinct shines with its own sufficient light, and seems at the moment the only eternally right and proper thing to do. It is done for its own sake exclusively. . . . To the broody hen the notion would probably seem monstrous that there should be a creature in the world to

whom a nestful of eggs was not the utterly fascinating and precious and never-to-be-too-much-sat-upon object which it is to her. . . ."

The Inner Conditions corresponding to Satisfying and Annoying States of Affairs.—Animals have their likes and dislikes, but whether their experiences during attraction or aversion are anything like ours, is a problem yet unsolved. In a previous chapter it was pointed out that some of the introspective psychologists have assumed that the feelings of pleasantness and unpleasantness are primary conscious states. Some believe that the conscious state, pleasantness, invariably accompanies the experiences that are sought and cherished, and that unpleasantness accompanies the states of affairs that the individual attempts to avoid. While it is probably true that pleasantness goes with tendencies to cherish or cling to, and unpleasantness with a tendency to turn away or avoid, in the case of human adults, there is no certainty that the hen, the fly, and other creatures—indeed, there is no certainty that human infants—experience the same or even similar conscious states. There is a need of technical terminology here which will cover the facts without implying necessarily what the introspective psychologist calls pleasantness or unpleasantness.

Thorndike has suggested for this purpose the terms *satisfying* and *annoying,* or *satisfying states of affairs and annoying states of affairs.* "By a satisfying state of affairs is meant roughly one which the animal does nothing to avoid, often doing such things as attain and preserve it. By an annoying state of affairs is meant roughly one which the animal avoids or changes." These definitions, it will be noted, are given in terms of what a man or animal does, not in terms of states of consciousness. They are generalizations based upon the objective study of hu-

man and animal behavior, not upon introspections of mental states.

It is quite probable, however, that the satisfying state of affairs is generally, if not always, experienced as consciously pleasant, and annoying states of affairs as unpleasant, in the case of human subjects. The conscious states and the observed behavior of avoiding, on the one hand, and attaining and preserving, on the other, are probably related to more fundamental, but as yet, unknown organic conditions. Annoyingness is probably indicative of one kind of subtle condition or change in the neurones; satisfyingness is a symptom of another kind of condition or change. What these conditions or changes are is as yet unknown although there have been many speculations. The concept of satisfying and annoying states of affairs, while not explicable on the neurological side, is so well justified by study of observable behavior, indeed, it is so invariably essential to the explanation of observable activity, that it must be accepted as one of our fundamental "working hypotheses."

Our hypothesis, briefly stated, is as follows. Original nature is such that certain conditions satisfy and other conditions annoy. The basis of satisfaction and annoyance is probably some fundamental organic or neural condition or change. In the case of human individuals at least, one symptom, although perhaps not an invariable symptom, of one type of inner condition is the conscious experience of pleasantness, while a symptom of another type of inner condition is unpleasantness. The symptoms of the inner conditions which we may observe in another person, are, in one case, the tendencies to continue in or repeat the activity which produces that inner state, whereas in the other case, there are tendencies to end or avoid the activities or conditions which cause that inner

state. The one condition, we may for convenience speak of as a satisfying state of affairs, the other as an annoying state of affairs.

The Relation of Instincts to Satisfiers and Annoyers.—Study of human instincts throws light upon conditions that satisfy and annoy. Instincts, we found, consist of mechanisms which are activated by stimuli arising in an external situation or in an inner bodily condition. The stimulus arouses a state of readiness or an urge to a further or consummatory response. We have observed that to eat when hungry, to rest when tired, to secure social approval, or to overcome an obstruction, is satisfying, whereas to fail to secure food, rest, social approval, or to remove the obstacle is annoying. We may cover these, and other facts of the present and preceding chapter by the following generalizations: (1) When an instinct is ready to act, for it to act is satisfying. (2) When an instinct is ready to act, for it not to act is annoying. (3) When an instinct is unready to act, for it to act is annoying.

Of the first two generalizations, abundant illustrations have already been given; of the last, a few will be sufficient. Instincts are not always ready to act. When one is satiated with food, one is unready to eat, one will attempt to avoid eating. That is, when unready to eat, to be forced to eat is annoying. When one is unready to engage in physical activity, to sleep, to rest, to be approved, to fight, to be among other humans, or to act in some other way, to be forced to do so is annoying.

These are the fundamental generalizations of dynamic psychology, that branch of the science which treats of the effects of forces in producing action and the laws of action thus produced. Each instinctive tendency has its influence in favoring some lines of activity and opposing

others. It is the relation of an act to states of instinctive readiness and unreadiness which determines in a large measure whether the act shall be repeated and thus learned, or whether it shall be avoided and thus fail to survive. Thus much of human learning is directed and determined by our original equipment of reaction tendencies.

QUESTIONS AND EXERCISES

1. Describe the mastery instinct in terms of elementary mental states and processes (See Chapter V).

2. Attempt to group the instincts enumerated (1) according to the purpose served by each; (2) according to the reaction made. What difficulties are encountered?

3. What are some of the specific activities which make up what we call the instinct of manipulation? Name in each case, as well as you can, the exact stimulus and response.

4. Analyse as well as you can the instinctive and acquired elements involved when an individual who is reading a book suddenly finds himself laughing or weeping.

5. What evidence have you to show that it is or is not instinctive to catch an object (as a ball) which is thrown toward one. How universal is this reaction? From what per cent of your fellow students would you secure it? Of young children? Of old people? What other reactions may be found?

6. Which of the instinctive tendencies listed in the chapter do you experience most frequently during the day? Which least frequently?

7. Is the fighting instinct as strong in women as in men? How would you go about discovering the facts by scientific investigation?

8. If it is instinctive to enjoy learning, acquiring skill and reasoning, why is it that so many people are content to remain rather ignorant and unskilled?

9. Is there an instinct of curiosity?

10. Are there native satisfiers and annoyers which do not depend, for their existence, upon any instinct?

11. Doubtless nearly every boy who has heard of a "Radio"

would like to have one. Is there an instinct to possess and use "Radios"? If not, how would you explain the boys' desires?

12. What situations in modern city life tend to provoke the fighting instinct? At what age is fighting most prevalent?

13. Why do people like to "tease"? Why do boys like to break windows, steal apples, torment peddlers, etc. Is there a sex difference in instinctive tendencies behind these acts?

14. Are people generally "thrifty"? Do we collect and hoard too much or too little? How would you induce children to save money?

15. In what way has the collecting instinct been utilized in school? Can you suggest further uses?

16. What are the instinctive roots of adornment? Is it a specific instinct? Would a person living alone adorn himself much? Do men or women give more attention to adornments? Explain.

17. Are there instinctive tendencies to "make beautiful objects," to "construct" or "to destroy," which have not been listed elsewhere?

18. Why do children play? What do they play? Consider any game. Are native activities involved that are not accounted for under the instincts?

19. Which of the foregoing instinctive tendencies are most prominent? Which ones persist through adult life? Which ones become stronger in adult life? Which ones always express themselves rather directly; which ones are modified greatly in the form of expression? Which ones are taken into account by religious doctrines or public laws?

20. Name a dozen things which people do to secure social approval. Evaluate the strength of this instinct. Trace its development to maturity.

21. Name a dozen instances in which a slight suspicion of disapproval brings great mental discomfort.

22. How may the desire of social approval and annoyance at disapproval be utilized in the school to serve desirable ends? How may the tendencies themselves be wisely modified?

23. Approximately 50% of the population of the U. S. (1920) live in large cities. Why?

24. How much would you pay to see a good football game if you were the only spectator on the bleachers? Explain.

25. When does the child begin to show "self-assertion" (mas-

tery)? How does it appear? What are the reactions when he is hampered or suppressed? How do habits of stubbornness arise? How would you deal with a stubborn boy?

26. To whom does the 2, 6, 10, 15-year old instinctively submit? Who most thoroughly arouses his self-assertion? To what extent are these tendencies to be encouraged or suppressed?

27. What are the main instinctive roots of the boys' gang activities? At what ages are they most prominent? What specific activities are most prominent in them?

28. Which instincts are of very great importance as drives or motives in the case of the teacher, the minister, the lawyer, the politician, the prize fighter, the argumentative person, the bashful man, the I.W.W., the Salvation Army, Red Cross?

29. In what cases do some of the "social instincts" seem to be very weak?

30. What instincts operate to make the following activities satisfying or annoying: the dance; a male group hike into the country; Christian Endeavor activities; hazing of freshmen; football for the players and for the spectators; smiles to acquaintances; praise of virtues; factory labor; domestic labor; sheep herding; confinement in prison; wearing war medals; wearing fine clothes; giving a big party; riding in a Ford; in a Peerless; appearing in informal clothes at a formal dinner; facial blemishes; being a spendthrift; being "a jolly good fellow"?

31. Read some short story and give the instinctive motives for the various things said and done.

32. Think of various friends: What are the chief instinctive drives behind their general or specific behavior?

REFERENCES

To the titles listed at the end of the preceding chapter may be added John Watson, *Psychology*, in Chapter 7 of which will be found the results of a study of the native activities of infants.

CHAPTER VIII

THE EMOTIONS

Any of the instinctive responses, described in the last chapter, could have been broken up into several components. In addition to the conscious awareness of the stimulus, we could identify: (1) movements of skeletal muscles, such as running, striking, defending; (2) facial expressions, such as the disgusted, angry, or fearful look; (3) activities of smooth muscles in the arteries, stomach, and other internal organs; (4) activities of the duct glands, such as the sweat, lachrymal, or gastric; and (5) activities of the endocrine glands, such as the thyroid or adrenal. In the main, the descriptions of instincts were limited to the gross bodily acts, but actually nearly every situation which aroused outward acts also aroused changes in the inner, hidden activities of the smooth muscles and glands.

Definition of the Term Emotion

The body is well supplied with sense organs and sensory nerves by means of which the inner (or organic) responses may be felt. That is to say, sensations may be aroused by the activities of the organism; we may feel our reactions as well as the stimuli which arouse them. The ordinary smooth-running bodily activities, such as respiration, circulation, digestion, and moderate activities of the skeletal or facial muscles are not conspicuously con-

scious. We become adapted to them as we do to the pressure of our clothes, the noises of the street, or the odor of our dwelling. But a stimulus, such as the sight of a snake, may cause a contraction of muscles, an increase in heart action, hurried breathing, and other inner changes, which become vividly conscious. When the bodily response is rather profound and widespread, involving particularly the visceral and glandular mechanisms, the resulting complex of sensations is called an emotion.[1]

Notice that emotion, as a psychological term, refers to the state of consciousness; that is, to the complex of sensations and not to the bodily activities themselves. Almost every stimulus to which we react outwardly arouses inner responses to some degree, although the organic reverberation may be very slight in many cases. If to a subject comfortably seated, slight odors, tastes, tactual stimuli, or meaningful words are presented, very delicate instruments will record slight changes in respiration, blood pressure, and glandular activities. But these inner changes are often too slight to become vividly conscious; the subject is unaware of their existence. Only those organic changes which are rather vividly felt are called emotions.

The term emotion, however, is not applied to the feeling of relatively simple or readily localized activities such as hunger, thirst, the burning or gnawing of indigestion, nausea, suffocation, or palpitation of the heart; nor do we speak of one kind of bodily sensation, however diffuse, such as general muscular fatigue, fever, or chills as an emotion, although the latter is an approximation. No, the genuine emotions, such as fear and rage, are much more diffuse, mixed, unanalyzable groups of sensations than any of these. They represent changes which per-

[1] Reread also p. 104.

FIGURE 21 The facial expressions characteristic of several emotions. Name them and compare your judgments with those of others (From Ruckmick.)

vade the whole body, and among them the smooth muscle and glandular changes which are controlled by the autonomic nervous system are most conspicuous. In fact, unless an experience possesses a considerable organic reverberation—strained or irregular breathing, palpitations of the heart, flushings and palings, quivers, sinking feelings in the stomach, tensions of the arteries, and other changes especially in the viscera—we do not speak of the mental state as an emotion at all.

The Outward "Expressions" of the Emotion

We recognize general bodily postures that are characteristic of certain emotions: we speak of being rigid with fear, bent with grief, or puffed up with pride. The expressions of the emotions appear more uniformly, in patterns of response of the facial muscles. That many of them have an instinctive basis is indicated by the fact that they are, so far as may be observed, universal and fairly constant reactions. If the reader will observe the plates (Fig. 21) he will be able to identify most of the emotions "expressed," although the face is unfamiliar, and much, such as color and movement, is lacking.

The emotional expressions may serve the purpose of influencing the behavior of other organisms. The display of teeth, and other angry expressions along with hissing, growling, barking, etc., may be conceived as instinctive forms of "bluffing" which may frighten off smaller or less courageous opponents. Notice the transformation in size and ferociousness of appearance of a cat when menaced by a strange dog. Similarly the human expressions of derision, scorn, disgust may modify the acts of others. Smiling, or a "sad expression," although their origin is obscure, invite kindly and sympathetic behavior. The

erect, puffed-up attitude of pride may beget admiration or submission.

The wide-open eyes in wonder or surprise are an adjustment which provides a wide range of vision. The narrowed eyes in anger are a kind of visual concentration on the object of attack, while the puckering of brow and closing of lids serve to protect these vital organs from injury. The slowing of breathing, in the first stages of fear, provides for more adequate hearing. Sniffing and pricking up of the ears in animals are sensory adjustments to slight stimulation. Much of the expression of an emotion, then, is the result of sensory adjustments.

Gritting and display of the teeth in anger among animals are motor adjustments for attack. Humans, under primitive conditions, may have used their teeth as weapons; the tenseness of muscles about the jaw is a result probably of these adjustments. The widened nostrils in fear or anger permit more effective breathing; clenching the fists and other muscular tensions have obvious utility. The bristling of hair about the neck and other preparatory reactions of animals belong here, too. The turning aside and wry face in disgust probably originated in the infant's response to undesired food or to noxious odors. The expressions under emotion, then, are in part the result of adjustments for motor response to the exciting object.

The Nerve Control of the Internal Emotional Changes

The internal changes which provide the major portion of the sensations that constitute the emotion are under the control of the *autonomic* system. The nerves of this system, connected through synapses with motor fibres which issue from the spinal cord and brain stem, are sub-

ject to nerve impulses received from the central nervous system. By means of inborn connections, the organic activities may be accelerated or retarded by pains, noises, odors, or other forms of external stimuli.

The autonomic system is divided into three groups of nerves:

1. The cranial division, connected with the upper part of the cord and mid-brain.

2. The sacral division, connected with the lower part of the cord.

3. The sympathetic division, connected with the intermediate part of the cord.

The cranial and sacral divisions, although supplying different regions, have a similar function which is always antagonistic to the function of the sympathetic. The cranial division depresses the activity of the heart, whereas the sympathetic stimulates it to greater activity. The cranial increases the glandular and muscular activities of digestion in the upper, and the sacral in the lower part of the intestines, whereas the sympathetic diminishes these activities in both regions. In general, if the cranial or sacral division accelerates, the sympathetic depresses; if the former inhibits, the latter stimulates; that is, they are antagonistic.

Since the divisions of the autonomic bring about different internal reactions, the emotional states which go with them must be distinctive. This, in fact, is the case: the sympathetic is involved in the strong emotions of which fear and anger are the best examples; the cranial and part of the sacral division go with mild, pleasant states, such as general bodily comfort and pleasure; while part of the sacral is concerned in lust and sex excitement.

The sympathetic system, although tremendously complex, embracing nerves discharging into nearly all of the

smooth muscle and glandular mechanisms, acts very much as a unit. The innervations may be slight or profound but in either case the effects are widespread. The cranial and sacral divisions do not act invariably as units; they permit of specific innervations of the different bodily organs.

Internal Changes in the Strong Emotions

Marked changes in the digestive and assimilative functions are brought about by innervations of the sympathetic system which occur in fear and anger. If a cat which has been fed a meal of gruel containing bismuth, a substance opaque to X-rays, is placed before the screen of a fluoroscope, the normal rhythmic, churning movements of the stomach can be clearly observed. If the cat is angered by a barking dog, these movements (of peristalsis, so-called) may be greatly diminished; in fact, they often cease altogether. Even in milder vexation, such as that produced by tying a small stick to the cat's leg, the stomach movements may be inhibited. The glandular activities of digestion are similarly diminished or stopped. the flow of saliva may stop, producing the dry mouth characteristic of fear, rage, or nervousness. The secretion of gastric juice is similarly diminished. In a typical experiment on an angered dog, instead of the usual 65 or 70 cubic centimeters of gastric juice, less than 9 cubic centimeters (and this of poor quality) were secreted. Thus the whole digestive process is side-tracked.

What purpose could all of this serve? None is very apparent save this—the elimination of the work of digestion liberates a good deal of energy that may be otherwise utilized. That such energy is conserved for strenuous muscular action is probable.

With anger or fear go also pronounced circulatory changes due to sympathetic discharge. The heart beats more rapidly and with greater amplitude. The arteries of the abdomen are constricted, thus driving large amounts of blood to other parts of the body, mainly to the skin, skeletal muscles, brain, and lungs. The constriction of arteries, together with increased heart action, produces a higher blood pressure and more effective circulation through the organs involved in bodily action.

The lungs are stimulated to greater activity; breathing becomes deeper and more rapid. Sweat breaks out on the skin, making an early start toward the elimination of heat from the body engaged in strenuous exertion. The sympathetic fibres also activate the adrenal glands whose secretion, adrenalin, poured into the rapidly circulating blood promptly reaches the various bodily organs and profoundly affects many of them.

As do the impulses of the sympathetic system, adrenalin diminishes the glandular and muscular activities of digestion, constricts the abdominal arteries, and stimulates the heart and lungs. It increases and prolongs the more prompt effects of the sympathetic nerves, and produces several additional changes. Reaching the lungs, adrenalin causes a dilation of small smooth muscles, which permits more ready ventilation, thus providing for a more speedy assimilation of oxygen and discharge of the products of fatigue. Adrenalin has a specific effect on skeletal muscles, greatly increasing their sensitivity to nerve impulses, which results in greater strength and endurance. Adrenalin causes the liver to pour into the blood more rapidly its store of blood sugar, the fuel which is burned in muscular work and also causes the liver to secrete a substance which makes blood clot more rapidly on reaching the air, thus reducing the flow in case of an injury.

The Emergency Theory of the Emotions

Other organic changes, characteristic of fear and anger, could be mentioned; but this, at least, is already apparent—the body is adjusted during emotion to provide for the greatest muscular strength and endurance. On the basis of this fact, an American physiologist, W. B. Cannon, has framed what he calls The Emergency Theory of the Emotions. The sympathetic system is conceived as an elaborate check and drive mechanism that is thrown into gear by events which demand immediate and energetic action; that is, by emergencies. Under primitive conditions, loud or sudden sounds, the perception of wild beasts, unfamiliar men, obstinate obstructions, and other objects or conditions which arouse fear or anger, represent situations in which physical strength and endurance, as in the fight or flight, may enable the organism to survive. It matters relatively little that digestion is inhibited, the heart or lungs overworked, if the animal successfully meets the emergency.

The organic responses, then, are preparatory reactions—elaborate mobilizations for violent and prolonged physical action. The emotions of fear and anger, as conscious states, are, in the main, the sensations occasioned by these inner changes.

Classification of the Emotions

The sympathetic system, it was said, is antagonistic to the functions of the cranial and sacral autonomic. Innervations of the latter tend in general to promote the quiet, normal organic processes of digestion, assimilation and excretion—the quiet service of building up bodily resources. Stimulation of certain nerves of the cranial

division increases the flow of saliva and gastric secretions, dilates the blood vessels of the viscera and promotes the action and tone of the stomach and alimentary canal. Other nerves of this division slow the heart, thus resting the cardiac muscles. Certain nerves of the sacral division are concerned with the proper regulation of the bladder and the lower alimentary canal.

Innervation of the visceral organs by the cranial and sacral nerves tends to arouse quiet, pleasurable emotional states for which we have but few names. A comfortable state of "well-being" is about all there is to it at times; and the mild emotions of mirth, of pleasure in hearing music, of joy in one's work, in agreeable conversation, comradeship or surroundings, harmonize with the upbuilding internal services of the body. Under such mild but pleasurable mental states we are best fitted for most of the tasks of daily life.

Aside, then, from the sex emotions and the mild, pleasurable states of well-being which go with the action of nerves in the cranial and sacral autonomic, all other genuine emotions, so far as is known, result from innervations of the sympathetic system.

The emotions which are known to go with sympathetic action may be listed in several groups:

1. Anger, and other similar states, such as rage, fury, vexation, irritation, revenge, and perhaps jealousy and scorn
2. Fear, and similar states, such as dread, anxiety, worry, melancholy, terror and perhaps grief and regret
3. Excitement, shock, uneasiness, nervousness, embarrassment
4. Extreme pity, sympathy, elation, enthusiasm

Other Components of an Emotional Experience.— The organic changes which characterize fear, anger, excitement, and other states are very much alike, at least in the more obvious features. But most people find the experience of "being afraid" very different from "being angry" or "being excited"; and these differences cannot, at the present time, be accounted for by organic changes, although it is possible that very important physiological variations await discovery. The total experience, however, always includes other components which are not emotions but fuse with emotions in a unitary state of consciousness. There is the perception of the exciting object: in the one case, a wild animal; in another, an aggravating man; in a third, a critical audience. There are also memories or anticipations, ideas of all kinds which are fused with the persisting organic sensations; and to them may be added differences in gross bodily attitudes and facial expressions. But perhaps most important are the differences in impulses. Fear, while organically similar to anger, is accompanied by an impulse to escape; anger, by an impulse to attack. The impulse is a definite adjustment toward some end—to turn and run, to hide or to strike, kick, seize, and choke—whereas the emotion is a diffuse group of inner changes which fit one of these ends as well as another.

If two boys are engaged in wrestling, each is subject to a general impulse to down the other, and, in the course of the contest, to many particular impulses—to hold an arm, to twist the neck, etc. There are percepts and other ideas, muscular strains, "feelings of effort"; but these are not what we mean by an emotion. Suppose that one boy, seeing defeat close at hand, loses his temper. If we could examine his organic processes, we would find them approaching a state of turmoil, which is the basis of the

emotion. Percepts, ideas, impulses, muscular acts, all of these are still present, and they may be much the same. The now enraged boy is still determined to down the other; he is still perceiving the other's moves and thinking of tricks to apply. The emotion *per se* is merely the sensations arising mainly from the internal changes.

Shock and Excitement.—Violent inner shock (which is due to very intense sympathetic innervation) or excitement represents the sheer organic changes very well, since the impulses are often vague and uncertain. Excitement thus resembles both fear and anger organically, but differs from both because of the indefiniteness of the impulsion. For example, a sound heard by a primitive man prowling in the woods might have aroused the sympathetic activities, experienced as excitement or uneasy alertness, until the source is more clearly perceived. If the stimulating object is found to be a ferocious beast, the percept with the impulse to run, added to the organic turmoil, constitutes fear; if the stimulus proves to be an old enemy, that percept plus the impulse to attack gives us the state of anger. The inner changes themselves, devoid of percepts, ideas, impulses and muscular adjustments, are felt as various degrees of inner turmoil ranging from terrific shock to slight excitement.

Exciting Joy, Enthusiasm, etc.—The violent or exciting states of mirth, joy, pity, zeal, enthusiasm, and the like are included in the list of emotions which depend upon the activity of the sympathetic system. Suppose, for example, that you are quietly enjoying a concert. If the music becomes very stirring, you may experience a glow, a pang in the breast, a fulness of breathing, a flutter of the heart, a shudder or darting chills, a sinking

sensation in the region of the stomach—evidences of the discharge through the sympathetic. Joy, on other occasions, may become so violent as to produce weeping, labored breathing, high blood pressure, and digestive disturbances. Enthusiasm, especially in people of the emotional or excitable type, may become so exciting as to make quiet work or thought impossible. Thus, in the intense, exciting, or violent form, joy, enthusiasm, pity, and others belong in the sympathetic group.

What, now, about other emotions, of joy, pity, reverence, gratitude in milder form? The mild but pleasurable states accompanying effective organic and visceral processes of the upbuilding type have been mentioned. But the language abounds with names of additional emotional states: wonder, timidity, gratitude, admiration, suspicion, coyness, pride, hope—what of them? Most of them are, in scientific literalness, not emotions at all; they represent impulses or activities which may or may not be accompanied or followed by emotions. Wonder and timidity represent conditions of conflicting impulses, to approach and to recede, along with various percepts and ideas and motor acts without any marked organic change. The organic changes in pride, hope, coyness, and admiration may be nearly negligible; that is, these states are not themselves primarily emotions, although when thwarted or exaggerated (as is the case with other impulses) the emotion may arise. When these impulses are accompanied by sufficient inner disturbances to make the term emotion applicable, it usually means the action of the sympathetic system.

The violent emotions, then, represent preparatory reactions in the form of mobilizations of organic and visceral resources for the maximum physical exertion. Under conditions of primitive life in the jungle, their

utility in contending with human or animal enemies, with storms, floods and natural forces would be apparent. In modern life, they might be of service in similar exigencies, but ordinarily they begin and end without the physical exertion for which they are a preparation. We are often angry but seldom fight; often fearful, without flight.

The Effects of Strong Emotions

On Health.—What are the results of emotions, such as rage, anxiety or fear, when they are not accompanied or followed by physical exertion? Indigestion is one result. The angered cat showed stagnation of food in the stomach from three to six hours on different occasions. Among humans anger, excitement, sorrow, and extreme joy are often followed by more or less severe digestive disturbances. Loss of appetite and weight under prolonged sorrow, anxiety, or worry is often observed. The blood sugar liberated by the liver when not utilized as muscular fuel is partly wasted by excretion through the kidneys. The general wear and tear on the heart and arteries, the adrenal and other organs which are driven to excessive action during the strong emotions, may in the long run be injurious. At least, it is commonly believed that the excitement, worry, fear, anger, and irritations of life hasten the breakdown of the visceral functions and it is well known that diseases or deficiencies of these functions are greatly aggravated by emotional disturbances.

On Skill, Thought and Ability to Learn.—However greatly crude strength may be increased under the strong emotions, anger, fear, or excitement, efficiency in acts of skill, in judgment and reasoning, and in learning is

decreased. The excited or angered baseball player fumbles the ball. The frightened youth forgets his "piece." An inventory of the experiences of skilled musicians disclosed an almost universal conviction that any exciting emotion aroused by the audience, or even an emotion normally aroused by the music itself, is detrimental to proficiency. Even in boxing, where strength assuredly counts, it is well known that skill is disrupted by rage. In golf, tennis, and other sports requiring great precision, the disastrous effects of anger, chagrin, nervousness, and anxiety are patent.

Thinking, reasoning, judgment are, like skill, disturbed by the strong emotions. In melancholy, ordinary tasks or debts look herculean. Frightened by a cry of "Fire!" the audience falls into an irrational panic; the drowning man strangles the swimmer who attempts a rescue. Even for murder, the leniency of the jury is generally assured if the act was committed in a passion. Violent emotions represent, in effect, internal preparations for violent acts, and even the less intense grief, fear, vexation, or excitement may lead to thoughts, words, or acts that seem unwarranted or ridiculous in calmer moments. In laboratory studies, although violent emotions are seldom secured, the general tendency of the milder ones to disturb acts of thought or skill appears clearly. Such tasks as tracing the outline of a pattern which is observed only by reflection from a mirror (mirror-drawing) or performing a difficult feat in mental arithmetic are retarded and sometimes disrupted by vexation, anger, chagrin, anxiety, or even by too exciting enthusiasm. It is characteristic of the novice to be subject to frequent emotional upsets. As the learning progresses, greater poise is achieved. Generally speaking, the highly efficient performance is characterized by a quiet alertness and unemotional

zeal rather than by excitement or emotional enthusiasm.

On Stimulating Activity.—The notion that the strong emotions in the routine of life render a tremendous service by providing impulsion to greater accomplishment, that they represent the release of hidden springs of energy, is likely to be very misleading. That they do provide a temporary increase in muscular strength we have seen, but this is attained at no small cost nor can it be long maintained. The athlete may run his quarter mile better if excited (although many prefer to be calm), but if he is "on edge" too long before the race, he may be half exhausted before it begins. The exhausting effects of a public performance by the uninitiated, of a frightful or grievous experience, are familiar to all. "What," asks David Belasco, "would be the condition of a player who, every night for even one week, should really feel all of the emotions of Hamlet or Othello or Lear; of Queen Margaret or Lady Macbeth or Juliet?"

But is the strong emotion not of great utility as an occasional upheaval to arouse us out of complacency to fresh resolution and determination, to set the ball rolling? If a student feels he is losing his interest in his studies—going stale—would not the part of wisdom be to arouse somehow in himself profound disgust, or anger at his lethargy, or vivid excitement by anticipation of the rewards of greater achievement? It would seem so; and perhaps the answer would be affirmative if there were not better ways. The physician often faces a similar situation. The patient reports bodily sluggishness and loss of grip. While pills or stimulants may be prescribed, the physician knows they are but temporary expedients which work no permanent cure. The remedy

lies not in drugs but in better hygiene; better habits of eating, sleeping, work, and play. The remedy for mental inertia is not in emotional stimulation but in improved habits of mental hygiene. A strong emotion, acting like a drug (for adrenalin and other glandular secretions are drugs), has the habit-forming effects of such artificial stimulation. If we rely upon coffee to keep us awake, shortly coffee is required in increasing doses. If we rely this week on emotional outbursts to get us at our tasks, we will the more surely require them the next. The emotional upheaval is like a drug, strictly an emergency measure, to be used only as a last resort, and then advisedly.

Must One Experience an Emotion in Order to Act It?

Admitting that the strong emotions are not essential and usually detrimental to the achievements of modern life, are they not essential to certain tasks, such as pleading in court, preaching, and other public performances? Could one make a stirring address or, what would seem to be more difficult, could one portray an emotion without really experiencing it himself? The testimony of great actors and actresses should furnish an answer to this question.

Many years ago, William James collected the statements of a number of leading actors and actresses and found a division of opinion. Many of the greatest were able to portray perfectly the outward appearance of emotions in face, posture, gait, and voice without the visceral and organic accompaniments on which the emotion chiefly depends. Others believed they were unable to affect the dissociation so completely. The few cases,

however (if they are correct observations), are enough to show that the inner turmoil is not essential to successful dramatization.

David Belasco, the eminent theatrical producer, has a decided opinion on the matter. "To assert that any actor must or even can really feel, when acting, all that he represents—assuming, of course, that he is representing any vital or even vivid emotional experience—is merely to maintain what is manifestly nonsensical. In acting, there never can be, in the very nature of things, any real feeling. . . . Nowhere are complete self-control, dominion, poise more absolutely essential to success than they are in acting and they cannot exist where sensibility is permitted to hold sway."

Mr. Belasco cites a number of anecdotes in support of his belief that great actors, even in playing profoundly emotional rôles, really maintain perfect self-control. For example: "One night when playing *Othello* in America, Salvini, as he spoke the final words, 'no way but this, killing myself to die upon a kiss,' and collapsed in his appalling simulation of death, murmured to Miss Viola Allen, the player of *Desdemona:* 'For the one hundred and third and last time this season!' "

The Need of Control of the Emotions

While it is possible, as actors and actresses testify, to portray the facial, bodily, and vocal features of an emotion without the inner turmoil, the more common modification in every-day life is the elimination of the outer expression, while the internal disturbances hold sway. We experience anger, fear, or sympathy without obvious motor response. Indeed, the emotions may come to be highly satisfying, as in the case of the few who

greedily study the daily paper for fresh incentives to grieve idly at the world's sufferings, rage at its vices, and exult at its achievements without contributing in any way to the relief of suffering, to the abolition of vice, or to the increase of achievement. The emotions might be defended on the ground that they are intensely satisfying, that they add to the color and variety of life and break up the drab monotony of routine. It would be a sorry world for most of us were there no pity, no indignation, exaltation, or excitement; even fear, anger, and grief—under certain circumstances—are satisfying. If we can experience these emotions with little likelihood of serious consequences, as we may enjoy fear in a storm-tossed ship if assured of safety, or anger and grief from scenes on the stage or screen, it is undeniably pleasant, as our willingness to pay substantial prices for these experiences amply attests. What is needed, of course, is temperance and wise control. The main dangers lie in the possibilities of permitting emotional enjoyment to become debauchery or a substitute for action. Not only are worthy impulses with less internal turmoil more desirable from the standpoint of personal efficiency and health, but the world is better served by *acts* of relieving suffering, and resisting oppression than by reactions which begin and end wholly in one's breast.

General Emotionality

Individuals differ in their general emotional responsiveness. At the one extreme are the calm, stolid, imperturbable individuals; at the other the excitable, sensitive, and easily aroused; and from one extreme to the other we pass through degrees of emotionality insensibly minute.

The concept of general emotionality is not unlike the concept of general athletic ability, general strength, or general mental ability. Two people at approximately the same stage of emotionality are not necessarily identical, but are like two people of about the same general athletic ability, who are alike only on the average, while different, more or less, in each of many particular forms of athletic prowess. Averaging up the emotional reactions to many situations, we arrive at a rough central tendency and it is to this that the term general emotionality refers. The cases of great general emotional susceptibility, or of great emotional lethargy, need not represent a particular lack or deficiency in one's equipment nor some super-added defect, native or acquired, but merely the extremes of a group of tendencies possessed by all.

An excess of emotionality is the main characteristic of one extreme. All or nearly all emotions may be excited by stimuli, numerous and slight, more than is the case with average people; joy, fear, sorrow, melancholy, and excitement are easily and frequently aroused. Not only are emotions easily and often aroused, but they are usually intense; joy is for them often explosive and riotous, anger becomes violent rage, sorrow becomes intense grief.

While there are individuals predominantly sorrowful, or mirthful, or easily angered or affrighted, the more commonly found case is the individual who is susceptible to all or nearly all forms of emotional response. As a general rule, the child readily susceptible to one form of emotion is readily susceptible to others. The child who laughs the heartiest, most readily breaks into tears; adults capable of the most enraptured pleasure are susceptible to the deepest sorrow or the most exquisite pain.

The most readily enraged may be, in turn, the most compassionate; the most ferocious, the most fearful. The sympathetic system, in all of these cases, seems to be hyper-sensitive and hyper-active; easily thrown into gear and unusually intense in its response to stimuli of many sorts.

Generally, but not invariably, extreme emotional sensitivity is characterized not only by emotional excess but also by emotional instability. The emotional child often shifts abruptly from laughter to tears, from affection to anger, from self-confidence to pessimism. In this fickleness, the emotional sensitivity and excessiveness of response can usually be recognized, despite the fact that other types of instability, more mental than emotional in character, making up what is called the "psychopathic" or the "neurotic" constitution, are frequently found in the same individual. Indeed, excessive emotionality and nervous and mental instability are often difficult to distinguish. Of the latter, something will be said in the next chapter.

The extremely unemotional individual is less easy to detect and his behavior is a less serious matter with the exception of the infrequent cases caused by actual disease. The least emotional individuals are by no means unemotional, but are aroused less frequently and less intensely. The mechanism of the emotions, designed for emergencies, is rather easily aroused even in those relatively unresponsive. It is the over-emotional rather than the under-emotional who experience difficulties in adaptation to modern conditions.

In the emotional child the sympathetic nervous system, it would appear, is readily innervated, bringing about the train of visceral changes previously described. How serious these disturbances may be depends, of

course, upon the soundness of the organs themselves; but indigestion and intestinal disorders, disturbances of circulation and of heart action, nervousness, insomnia, general weakness, and fatigability are frequently found. With the internal activities of the body more than commonly at the mercy of the external conditions, more than ordinary care and prudence must be exercised to avoid overtaxation of reserves. The emotionally unstable child usually cannot indefinitely keep pace with those of greater poise but otherwise of equal endowment.

In the work of the school, the handicap of excessive emotionality usually becomes apparent. Pupils of high mental abilities who are otherwise sound, except that they are very emotional, experience difficulties in holding themselves down to continuous, especially monotonous, work. Drill in spelling, arithmetic, phonics, and writing is carried on sporadically. In the formal aspects of these subjects, the emotional child lags behind his intellectual possibilities. He lacks the capacity for steadiness and persistence of concentration which such functions demand. His attention flags and shifts before the lesson is well under way. Special interests, more individual attention, shorter periods of practice with frequent change, an abundance of physical freedom, and other special forms of treatment frequently enable the emotional child to make greater achievements.

QUESTIONS AND EXERCISES

1. What evidence is there that emotions are instinctive forms of response?

2. How would you distinguish an emotion from an impulse? Illustrate.

3. Observe an infant or a child who is experiencing some emotion. Describe the facial and bodily movements, and other

"expressions." In what respects are they preparatory reactions and how do they affect the behavior of others?

4. What emotions predominate at ages 3, 6, 10, 15, 40?

5. Can you offer any evidence in favor of the statement that grief, melancholy, anger, or fear are sometimes satisfying?

6. Is it wise to give way to an emotion when you feel the impulse?

7. How often does the average adult experience fear under the conditions of modern life? List some of the situations which provoke fear. Do the same with anger.

8. Can you think of situations, under modern conditions, wherein a strong emotion would be of utility?

9. What are some of the impulses which you have experienced when angry or frightened?

10. Were there cases in which the impulses changed while the emotion remained the same? Can you cite cases in which the emotion changed while the impulse remained the same?

11. Give samples of "irrational" fears, angers, melancholias, etc.

12. What emotions, chiefly, arise when you are physically tired, tired by mental work, hungry, or in states of illness, indigestion, uncertainty?

13. What people are, as a rule, more emotional: successful or unsuccessful, intelligent or dull, educated or uneducated? Which have the more irrational emotions? Which have the stronger emotions?

14. What account does the school take of emotional differences? What is done in the way of emotional training? At what ages should emotional habits—keeping one's temper, resisting stimuli to fear, grief, anger, etc.—be established?

15. Is there any likelihood that an average person can learn to control his emotions completely? Why are we likely to be deceived in judging emotions and impulses from facial expressions of a temporary character? Of a permanent character?

16. Have you ever observed a child or adult whose emotionality was so pronounced as to interfere with health, happiness, or work?

17. Just what is meant by "general emotionality"? Arrange ten people of your acquaintance in order from the most to the least emotional? Are there also differences in susceptibility to particular emotions?

18. The pictures of facial expressions of emotions afford interesting material with which the judgments of children and adults may be tested. Take the series printed above and ask children of different ages to tell what the woman is doing, or what she is thinking about. Do the older children judge better than the younger? What kinds of emotions are specially difficult for children to judge? Is the same true of adults? Do children that excel in school work also excel in these tests?

19. Can you trace in your own experience or that of others the gradual development of *habits* of emotional expression, such as habits of "feeling blue," of being easily irritated, of persistent cheerfulness? Can you find cases of developing *habits* of "crying it out" when one is emotional?

20. What should one do when one feels like giving way to an emotional expression? Why?

21. How does the fact that children and adults are often easily upset when performing before an audience bear upon the discussions of the emotions? What emotions does an audience usually arouse?

22. Give in your own words, the substance of the James-Lange theory of emotions. Cite evidence in favor or in opposition to it? What kind of experiment can you suggest which might yield crucial evidence?

23. In what respects does the autonomic nervous system differ from the central nervous system? In what respects is the former subordinate to the latter?

REFERENCES

The James-Lange theory of the emotions is described by James in his *Principles of Psychology*, vol. II, chapter 25, and by Lange in an article entitled "The Emotions, a Psychological Study," which has been reprinted with James' chapter in a book *The Emotions*, 1922, forming vol. I of the *Psychology Classics*, edited by Knight Dunlap.

The emotional expressions of animals are best described in Darwin, *Expressions of the Emotions in Man and Animals*, 1872. The pictures of facial expressions in the chapter were taken from an article by C. A. Ruckmick in the *Psychological Monograph*, No. 136, pp. 30-35, 1921. Photographs of these and other expres-

sions may be secured by addressing *The Purchasing Agent, University of Illinois, Urbana, Ill.* Another series of pictures will be found in an article by Antoinette Feleky, in the *Psychological Review* for 1914, vol. 21, pp. 33-41.

For a description of the autonomic nervous system and a discussion of the internal changes during emotions, see W. B. Cannon, *Bodily Changes in Pain, Hunger, Fear and Rage,* 1915.

CHAPTER IX

THE DYNAMIC RÔLE OF INSTINCTS IN HABIT FORMATION

Original nature provides us with a host of tendencies to mental, emotional, and muscular activity. Events in the environment or in the body itself are constantly providing stimuli which arouse either immediate and conclusive responses, typically of the reflex type, or impulses and states of readiness for further activity which are more characteristic of the complex instincts. The same may be said of acquired reaction patterns. They, like instincts, are aroused by stimuli from within the body or from some feature of the external environment and, if delayed, appear as states of readiness or as conscious impulses to action.

Habits once well established operate in every respect like instincts. Many habits, however, are really the means by which native impulses are expressed, and habits, in this sense, are derived from instincts. There is a native impulse to manipulate and specific tendencies to make a number of particular hand and finger movements; but acquired forms of manipulation of toys and implements may satisfy the tendency to manipulation quite as well. In other cases, the acquired activities may be less directly, at least less obviously, akin to the native trait and yet activated by it. They are, as it were, native tendencies in disguise.

How Instinctive Tendencies are Thwarted

But why the need of indirect expression? Why do we not always, if we feel an impulse, carry it through to its consummation directly? The answer is that the conditions of life often thwart the direct expression. The child very early finds his natural impulses subject to discipline; he may not eat, yell, throw when and what he pleases. As he grows up, he finds that the life of the school offers other restrictions and each later year may add anew to the inhibitions of his conduct.

The sources of inhibitions of or restrictions upon native tendencies may be grouped roughly as follows:

1. Other antagonistic instinctive trends
2. Acquired habits, ideals, conventions, taboos
3. Obstacles in the environment

One instinctive trend may conflict with another or several others so that all cannot be gratified. Thus one's desire to accumulate may conflict with counter desires to rest, secure immediate sensory satisfactions, or social approval by immediate display. The impulse to mastery may conflict with the impulse to avoid injury in physical encounter. The impulse to experience the novel may conflict with fear of the unknown or with the satisfactions of familiar surroundings. The impulse to dominate, when the objects are our own children, may conflict with the parental impulse to treat them tenderly.

Instincts may be thwarted by acquired habits, ideals, religious beliefs, or social conventions. In time of war, instinctive fears of slaughter may conflict with ideals of patriotism. The native impulse to pick up attractive objects runs counter to habits and ideals of honesty. Beliefs established in childhood, religious and social training, or thoughts of consequences, may inhibit many

sex impulses. The strength of the instinctive tendencies to collect and hoard, to dominate, to fight, to scorn, to indulge sex are reflected by the Ten Commandments, and other religious as well as legal, economic, and social enactments. Were these impulses more easily and generally controlled, there would be little need of laws and courts, police and prisons, social taboos and prohibitions. The existence of these institutions and practices is perennial evidence of the conviction that all native activities are not socially desirable, and that many of them must, therefore, be more or less completely diverted or held in check.

Finally, original tendencies may be thwarted by natural obstacles or realities. Barrenness of the soil, floods or drought, business depression, or the superiority of rivals may thwart many native trends, as may the death of parents, partners, or friends. One's desire to secure social approval may be thwarted by a disfigured face; to attain mastery, by an unimposing physique or inadequate intellect. Injuries, illness, and other misfortunes are the more annoying because they foretell other thwartings. If we have a steady job certain cravings, such as those for rest, freedom of action, display of authority, may need to be foregone; if we lack a steady job, others such as the desire to accumulate, to eat abundantly, to secure approval, are jeopardized. No matter how favorable the conditions of life, the thwarting of native impulses and wants will be constantly experienced.

What Happens When an Instinctive Tendency is Thwarted?

What happens when an instinctive tendency, being in readiness to act, is by some circumstance not permitted

to act? A general answer to this question, given earlier, will bear repetition. Whenever an instinct is ready to act, for it to act is satisfying; and furthermore, whenever an instinct is ready to act, for it not to act is annoying. A satisfying state of affairs is defined as one which the animal seeks and attempts to maintain; an annoying state of affairs is one which the animal attempts to avoid—to which it reacts negatively. Both are conditions which demand activity and if the conditions are novel, the result of the activity is learning.

All of these general statements find concrete illustration in experiments upon a cat enclosed in a puzzle box. The animal is instinctively annoyed by such confinement and this provides the motive for efforts to escape. If the cat is at the same time hungry, food placed in front of the box adds another motive—a readiness to eat. If the way out of the box has been previously mastered or if the box yields to such activities as cats instinctively make in such a situation, the end results—escaping confinement and reaching the food—are at once accomplished. But if the box is unusual, the way out must be discovered by a series of trials characterized usually by many errors before final success is achieved. Here we have a typical form of learning; learning by "trial and error," as it is called. The cat bites, digs, claws, pushes, pulls, and makes other native and acquired responses to the several features, wires, slats, knobs, strings, openings, which the box provides; he tries and tries again, until finally the solution is hit upon, usually by sheer accident. Ordinarily the whole performance must be undergone a number of times before the "way out" reactions are thoroughly habituated.

In all essentials, man's behavior when thwarted in some instinctive tendency or when seeking to satisfy

some native impulse is like that of the cat in the box. He tries in one way or another to secure the satisfying and avoid the annoying state of affairs. He differs from the cat by learning the "way out" of the latter or the "way to" the former more rapidly and with better retention. He differs, furthermore, in his capacity to make certain *mental adjustments* to the perplexing situation; adjustments which, although involving ideas to a degree quite beyond the capacity of the animal, are achieved by the same "trial and error" process that characterized the cat's escape from the box.

When the native impulses to collect and hoard, rest, dominate others, fight, secure social approval or sex satisfaction, or to satisfy other wants are thwarted by obstacles, or when they come into conflict with each other or with our acquired habits, beliefs or ideals, some way out of the dilemma is sought by the try-and-try-again process; that is, by means of our capacity to learn. The adjustments thus made are obviously acquired reactions; habits acquired in the service of the instinctive trends.

Individual Differences in Ability to Tolerate Thwartings

Individuals moreover differ greatly in the degree to which they are annoyed by the thwarting of their wants as well as in the characteristic types of adjustment. Some people, we all know from observation, can maintain their poise in the severest storm of deprivation and misfortune, while others are disarrayed by the slightest swirl. Scattered between the two extremes are the other individuals, representing every intermediate degree but most thickly clustered in the middle of the group. Those

at the weaker end are often spoken of by students of nervous and mental disorders as "neuropathic," or "neurotic," or "psychopathic," which means, in a general way, easily upset, very sensitive to difficulties in adjustment, and consequently readily susceptible to nervous or mental disorders. The position which an individual occupies in the group, ranging from the most to the least "unstable," of which the "neurotics" compose the former end, is determined in the main by original nature, although disease, poisons, shocks, or hardships may pull one to a level far lower than his original position.

It is seldom easy to differentiate the neurotic or nervously unstable from the extreme case of general emotionality. In the purest form, the case of extreme emotionality represents merely an excessive organic reaction to stimuli. There may be internal disturbances of a violent type, momentary or persistent, with relatively little misinterpretation of the stimulating events. The individual may simply become readily embarrassed, chagrined, frightened, unnerved, angered, while quite aware of the irrational character of such behavior, just as many of us become more or less excited over a public performance while quite aware both of the irrational character and the futility of the perturbation. The emotionally unstable individual may make entirely rational and wholesome adjustments to his difficulties even though the difficulties are great, whereas the psychopathic individual is not only intolerant of his thwartings but is unfortunate if not irrational in his adjustments. Emotional susceptibility, however, predisposes to unfortunate adjustments and unfortunate adjustments may aggravate emotional susceptibility.

What is meant specifically by the extreme neuropathic or psychopathic dispositions can best be explained

by detailed consideration of particular adjustment tendencies, of which there are several forms.

The Mechanism of Introversion

One of the most familiar and certainly one of the most convenient ways of securing indirect exercise of a thwarted desire or trend lies in the substitution of imagination for actuality. Among children, the common day dreams of candies, cakes, toys, and fairies are samples. The imaginary companions of the lonesome child, which occasionally become phantasies, and the "white lies" due to confusion, in recollection, between the real and the fancied, are the products of similar mental mechanisms more extreme in their operation. Among adults, the same tendencies are found, working along grown-up lines and normally with little confusion with actuality. Excessive day dreaming of the realization of desires is technically called *introversion* (meaning to turn inward) and the extreme *introvert,* at least when subject to confusion of fact and fancy, would be commonly classified as abnormal or insane.

The "Conquering Hero" Type.—Among introversions there are several tendencies which are alike with respect to the mental processes involved and with respect to the fact that they are, in some way, clearly satisfying. Perhaps most common is the form in which various instinctive tendencies—the desire for social approval, for mastery, etc.—are gratified by playing one's self, in imagination, as a "conquering hero." One may picture himself as a hero in battle, on the gridiron, in the prize-ring; as a great bandit, singer, or preacher; as the strongest, most admired—indeed, as the superlative in any line, even in benevolence or modesty. By some

imaginary ability or achievement one becomes an extraordinary person—a conquering hero—to whom imaginary approval and applause are due.

These are perfectly normal and universal day dreams which bring much satisfaction and little harm to most people. But in the extreme form they may be disastrous; indeed, they resemble the *delusions of grandeur* found in *Paranoia*, a rather uncommon form of insanity. The victim of delusions of grandeur has become an extreme introvert or has somehow lost his grip on reality so that he believes and tells you at length that he is the strongest, wealthiest, or in some other way the greatest man on earth. Of course, these systematic delusions indicate neurotic organization to begin with and may be long in developing into the extreme form; but fundamentally they are achieved by the same kind of mental functioning which results in the harmless self-aggrandizement of youth.

The "Suffering Hero" Type.—Another tendency of imagination or introversion is typified by the ideal experiences of a suffering hero. While less common than the conquering hero variety, this form of imaginary experience is equally intelligible and equally satisfying, to some people, at least. The fancies may run something like this: a boy, ruminating over his hard luck and ill treatment (as he sees it) at home or school, pictures himself as forced to run away from home. He imagines himself joining a group of bandits and going to the bad completely, or perhaps overwhelmed by a snowstorm and wild beasts, by which he is injured or even killed. Meanwhile, parents, teachers, some little girl, in fact the whole village has become alarmed and repentant, and after vigilant search he is brought back a hero, even if a wounded one. But perhaps he dies, and if so, it is any-

thing but annoying for him to hear the imaginary obituary, in which his virtues, appreciated heretofore by none but himself, move the congregation to heartrending grief and remorse.

Introversions of this type are highly gratifying partly because the subject is, after all, a hero who achieves acclaim and partly because approval coupled with sympathy and pity are all the more sweet. Self-pity, which is typical of many neurotics, probably belongs in this general group, i.e., it is the outgrowth of introversion of the suffering-hero type.

The suffering hero mechanism is often behind such childish behavior as pouting, sullenness, pretended injuries or illness, refusals to eat or to play. If the new doll or dress is not quite up to expectation, the child is angered and will not have it at all. A real or imagined slight at the party sends the boy home in indignation or grief. As a rule, real actions of the wounded-hero type are cured more readily than are thoughts. The boy who refuses to eat finds, after all, that no one else is much disturbed, whereas he gets dreadfully hungry; he who leaves the party learns that he misses a great deal of fun without being himself missed. But the imagined acts of this sort come out more happily. Imaginary starvation is more tolerable, and the imagined remorse and pity caused by it can always be secured, whereas real sympathy from others is not always secured.

Some forms of *delusions of persecution* in the insane have many features in common with the suffering-hero introversion although others are developed in different ways. Overt acts of martyrdom, ranging from refusals to eat or play to the infliction of injuries, the simulation of illness or actual suicide, may be the outcome of prolonged or impulsive introversion of the suffering-hero type.

Identification

A somewhat easier and often more vivid substitution for genuine action of the sort instinctively desired may be secured by identifying one's self with the conquering or wounded hero or with other characters in fiction or on the screen or stage. When the boy reads *Treasure Island* or *Robinson Crusoe,* he actually becomes the adventurer. With *Nick Carter* he holds up trains, kills Indians, overcomes ferocious enemies, drops over Niagara, and has other experiences at which his original nature thrills but to which it scarcely dares lead overtly. Similarly, we may identify ourselves with the righteous and heroic sufferer, and weep real tears at our imagined hard lot. The heroes and heroines as well as their experiences may change constantly or, doubtless less frequently, we may persistently identify ourselves with a real or represented character, following his achievements in great detail. The rôle of the finest character or the greatest rogue, the most applauded or the most chastised, may be imagined with equally great satisfaction.

Within limits, and properly controlled, the play of imagination or identification is productive of little harm, while providing much satisfaction. The student, struggling without time or means for immediate gratification of his impulses, is comforted by the vision of wealth, power, and approval that he may some day attain. The introversions should be of the right sort. Imaginary achievements as a rule, if not invariably, are more wholesome than imaginary grievances. One may get along very well on imaginary power but not very well on imaginary food. Fancy must not disregard fact nor become a substitute for action. It is in this possibility

of imagining fine adjustment while achieving none that danger lies.

Rationalization

Mental adjustments may also take the form of *rationalization* although *irrationalization* would be the more descriptive if less commonly used term. Rationalization is a form of thinking or reasoning, that is, of sifting data, in which our personal desires are selective factors which guarantee an agreeable conclusion. Ideally, reasoning is the process of impartial manipulation of the evidence to achieve the logical conclusion, however disastrous the result may be to our own wishes. Rationalization means more or less complete blindness to all evidence except what furthers our side of the case. In every-day life this irrational process is often so subtle as to leave us oblivious of its existence.

A middle-aged man with a wife and family buys a handsome automobile. His older and more sagacious uncle, paying a visit, questions his motives in this purchase: "It seems to me," he says, "that you need furniture, a new fence, a fund for sending your children through college, a nest-egg for emergencies, more than you need this machine." But the buyer has a ready defense: "Well, my wife hasn't been any too well and I thought that a little week-end trip now and then would do her a lot of good. And a business man must have some recreation, you know! Then the children! They caught so many colds last winter because they got wet going to school"—and so on with other "reasons." Now, what were the real motives? Perhaps the fact that other neighbors had cars which were veritable badges of greater business success. Perhaps driving a big machine appealed to the instinct of self-assertion. Perhaps the

approval of on-lookers was the object sought. Observe the motives to which advertisements of high-class cars appeal!

The real motives often lie deeper than those we give, and what is equally significant, we often do not ourselves appreciate just what they are. Rationalization is a subtle process; it provides acceptable reasons while concealing the fundamental motive. The most effective temptations are those which come in disguise. If we are inclined to take the afternoon off for golf, while really aware that we should work, we at once obscure the real issue by rationalizations, by camouflaging the unworthy impulses. The student says to himself, "I have been working hard; I deserve a rest; I must be careful of my health; a little recreation will double my capacity to-morrow." And the next morning to justify faith in himself, the student rationalizes the sore muscles and aching back as symptoms of renewed strength and vigor; or the excessive fatigue as evidence that exercise was sadly needed. These excuses and explanations are as persuasive as they are irrational.

Projection

Failure to secure mastery, social approval, or other instinctive needs may be partly averted by a form of rationalization called *projection*. There is a universal impulsion to project the trouble to some cause other than our own deficiency. If, while groping our way across the room in the darkness, we thump our shin on a footstool (due to our own forgetfulness), our immediate impulse and not infrequent act is to reproach the footstool rather than ourselves. Missing a stroke in tennis, we look inquiringly at the racket, ball, or net.

The clumsy carpenter accuses his tools. If we fail in an examination, the questions were unfair. If one is a slave to alcohol, the taste was inherited from his father. If a man sins, it was because he was irresistibly tempted. If he amounts to nothing, it was because he did not have a chance. There was once a man who exclaimed when his carelessness resulted in the burning of his home: "It was the Lord's will."

By projection we escape the annoyingness consequent upon the admission of our failures and deficiencies. The chronic alcoholic, notorious for projecting the cause of his downfall, affords an example of this mechanism. It would be most painful to admit that one is not only a worthless drunkard but also the cause of untold suffering to one's wife and family. The chronic drinker, finding it impossible to give up the liquor, casts about, like the cat in the box, for some means of escaping these unendurable thoughts. Perhaps, some time as he arrives at home intoxicated, the wife indignantly drives him out of the house. Thinking the matter over at the corner saloon, it occurs to him that he would not be drinking now were it not for his wife. This affords a crumb of comfort. He broods over this and other real or imagined events until he has convinced himself that his wife has been, even from the beginning, the cause of his downfall. That these delusions free him from responsibility not only for his own ruin but for the sufferings of his family is motive enough for clinging to them tenaciously.

The "Sour Grapes" Mechanism and Its Converse

As the fable goes, a fox after many vain efforts to secure an attractive bunch of grapes, preserves his pride and assuages his appetite by declaring that the grapes

were sour; quite unfit for consumption by one of his caliber. This portrays a common method of human adjustment, a tendency to minimize or deny the desirability of the ends sought. If we lose our job through inefficiency we convince ourselves that the loss was a blessing in disguise. If we find masterfulness difficult to attain, we may say that more than anything else we despise pretentiousness. Being poor, we assert that money is the root of all evil. Unfit for or unsuccessful in marriage, we declare wedded life a failure.

A rather general belief in compensation among human abilities has arisen from this tendency—a conviction that people extraordinarily competent along one line must be deficient in another. If the other fellow learns rapidly he will retain poorly. The pretty girl has little sense. The highly intelligent are nervous, unstable or physically inferior. All of these generalizations are, in fact, incorrect and thus disclose the more clearly this unique human tendency.

The Converse of the "Sour Grapes" Mechanism.—A fox finding none but sour grapes declares that they are just the kind for which he had been searching. And so, Pollyanna finds that no matter what the calamity, one ought really to be pleased because it might have been worse. Living in a hovel, we declare it easier to keep tidy and much more comfortable than a big lonesome house. Lacking mastery, we find supreme virtues in meekness.

The "sour grapes" mechanism and the Pollyanna forms of adjustment betray a weakness. To declare that really desirable achievements or rewards are futile or depraving seldom uproots our wants, at least not those grounded in strong native trends. Furthermore, the fruits whose desirability was once denied later may fall

within our grasp, whereupon we must either scorn them again or else lay ourselves open to the attack of inconsistency.

Both forms of adjustment are negative—let things come as they will and make the best of them—rather than progressive. It is the adjustment of the inactive; the same old sour grapes are good enough. If they are really sour, it would be better to search elsewhere for sweeter ones. It is the opposite extreme of adjustment tendency from the behavior of one who, finding a high wall in the path of his progress, attempts to go under it, or over it, or around it, and, all of these failing, goes around the world to come up on the other side.

Logic-Tight Compartments

Systems of ideas developed by rationalizations of any type, beliefs, superstitions, prejudices, grudges, or habits developed in childhood or later often become so firmly established that they can scarcely be dislodged even in the face of substantial evidence that they are irrational, useless, or even harmful. Such acquired systems of response, impenetrable to logical attack, have been called *logic-tight compartments.*

Among the milder forms of logic-tight compartments are our convictions of the superiority of our town or county, our college, or ourselves. Several investigations have shown a very usual tendency for people, even those of high intelligence and broad training, to overestimate their abilities and virtues and in particular for those who are generally regarded, for example, as decidedly snobbish or vulgar to be blind to the facts. It is easy to see that these erroneous beliefs are motivated by our instinctive desires. In various ways we may close our minds

to the arguments which run counter to our desires and cherish those which favor them. In the course of time, these prejudices become fixed.

We may have closed minds in various degrees, ranging from the slight distortion of facts required to provide a comforting explanation of failure in an examination, or that of a male clerical worker who may not himself see any relation between his fear of competition and his conviction that "woman's place is in the home" to the extreme type of the man, who while scrubbing the floor of the asylum stops to tell you that he is a millionaire. While we would call the last a case of insanity and the first just a "natural feeling," both are similar mechanically, differing mainly in the degree to which misinterpretation is carried. The delusion of being a millionaire represents logic-tightness to a degree of absolute immunity to which the term *dissociation* is often applied.

Dissociation.—The psychologists and psychiatrists working with abnormal behavior find a great many types of dissociation. Persistent irrational ideas; loss of memories, of the control of the limbs, of sensitivity of skin or eyes or other sensory mechanisms; and "automatic" functions such as writing, represent dissociations of bodily or mental functions from the "main" personality. Ordinary associations fail to influence them.

What interests us in these abnormal conditions is that there is a constantly growing tendency to regard them as "escape mechanisms"; devices, not understood by the patient, but hit upon accidentally, which provide a "way out" of an annoying situation or which permit the exercise of fundamental trends that otherwise would be prohibited.

A badly pampered young man of a somewhat unstable

type began his career as an accountant. Before many weeks he was brought home complaining of severe pains in the eyes and in the right arm, which seemed partly paralysed. Feeling better after a few days' rest, he returned to his work only to find the attacks recurring. The significant thing about these symptoms is that they made his work in the office impossible. Actually, the young man found the tedious task at the desk, day in and day out, extremely boring, and the work deprived him of the freedom and comforts which home life had previously given. At the same time, he was naturally averse to quitting outright—that would offend his self-respect and bring the scorn of his friends as well. Perhaps, one afternoon the fatigue of eye and hand did become severe, providing an excuse for release from labor for the day. The next day, the same symptoms occurred in more severe form and, half frightened and yet half gratified, he was taken home. Not only did he thus escape the unpleasant work but the criticism of himself and of others as well. In fact, he reaps more sympathy, freedom, and general care than ever.

Substitute Activities or Compensations

The various forms of introversion and most of the forms of rationalization were mental adjustments to the situations which interfered with or inhibited the direct expression of native impulses. In one way or another some mental activity was substituted for overt action. More active adjustments may also be made even when the substituted activity is in most respects quite unlike the original form. For example, a man who has been enraged but who does not dare to give rein to his impulses to attack because of his fear of injury, or jail, or perhaps

because he doesn't believe in fighting, may substitute an attack with words or looks, or he may control himself for a long time but may later vent his rage upon his wife or children. In the same way, a man of frail stature, failing to secure a feeling of mastery by his physique, substitutes (quite unwittingly, perhaps) a dignified gait and manner, or develops a loud, "masterful" voice or a hard, even gaze. A woman, lacking beauty or wit, may, to secure approval, substitute gorgeous apparel or affect the élite in vocal expression. The unprepared student in writing his examination may compensate in volume for what he lacks in facts. A man low in the scale of authority at his place of work, submissive to others throughout the day, may find a satisfactory compensation in ruling his wife and children with a stern and unrelenting will.

Substituted activities may be good or they may be bad; some are very bad indeed. That addiction to alcohol, heroin, morphine, or other drugs may be considered as compensations for thwarted desires or ways out of annoying situations, is a growing belief. Dr. Richard Cabot, Professor of Medicine in Harvard University, writes: "We hear a great deal of the physical craving for liquor. I do not believe there is any such thing except in the people who are in the middle of a drunk. A person who has slept it off . . . may well enough go back to it and of course he often does. But he does not go back from merely 'physical' craving, but generally because he is bored or because he is blue or because he is restless." That Dr. Cabot had in mind thwarted impulses or annoying conflicts from which alcohol has provided an escape, is indicated in this further statement: "The alcoholic is helped, so far as he is helped at all, by getting at the reason why he started drinking and has continued to drink. Then if possible we try to find a stronger mo-

tive, a motive stronger than the thing that has driven him to drink and thus drive him out of drink."

A substitute activity, then, may get one into difficulties worse than the trouble which the activity aimed to relieve. But there are good as well as bad forms of compensation. If the maternal instinct is thwarted, better than idle day dreaming, or novel reading, or a pessimistic view of life, or "sour grapes" or a cheery indifference of the Pollyanna type, better than some silly or harmful compensatory activity, would be the substitution of some social, religious, or educational work. For the fighting, hunting, dominating impulses of youth, vigorous athletic games may be substituted. When angered, instead of holding a grudge, or inflicting damage on the offender in fancy, or working off the impulses by verbal attack upon inoffensive persons, we might attack the woodpile. A man who had lost his wife and children, in a terrible calamity, instead of avoiding the anguish by way of delusions, or liquor, or giving up to a wounded-hero type of self-pity, plunged more deeply than ever into his work and so instead of becoming a ne'er-do-well, a drunkard, or a pessimist, became a very eminent soldier. Of all the methods of adjustment to the thwarting of our fundamental impulsions, the substitution of some wholesome but vigorous activity, while not always the easiest to arrange, is by far the best. When the lives of men are deeply searched, great achievements are found in lines of activity which began as substitutes for some other interest that was thwarted.

Repression

In the writings of Freud and many other exponents of the "psycho-analytic" schools, the term " repression" into

the "unconscious" or "subconscious" appears extensively. According to many of these writers, repression is conceived as a subtle mechanism by which many thwarting or painful ideas or "conflicts" or impulses under taboo may be temporarily avoided by banishment from consciousness. Sex impulses (which the Freudians find to be most numerous) may arise in forms tabooed by our ideals or training. We cannot allow these impulses to be expressed directly or even by day-dreaming their realization. Attempts to rob them of their attractiveness by some form of rationalization, by the sour-grapes mechanism, for example, may fail. What we may do, according to the Freudians, is to relegate them actively into the sub-conscious; that is, to repress them. Once submerged in this lower region, they become unconscious—we become unaware of their existence—but though buried they are really buried alive. Still active, they may express themselves in some indirect way, often in most mischievous ways. They may come out during dreams—a time when our inhibitions are at a low ebb—in some symbolic or even direct form. During waking hours, the repressed ideas or impulses are more closely guarded by the "censor," that is, by our ordinary taboos and inhibitions. Their appearance then must be very deceptive; consequently they take the form of headache, nervousness, fears, forgetfulness, pains, paralysis, or stuttering. Even slips of speech or writing, difficulties in recalling a name, perseveration of a tune, or giggling are ways in which repressed impulses are satisfied. Many nervous disorders, it is said, are occasioned by these unconscious ideas and impulses. Such symptoms are unconscious motives in disguise.

When explained in detail, the Freudian concepts are fascinating and often convincing. Yet they have not

met with approval in most scientific, especially psychological circles. The trouble is, that while they fit in well with popular notions, the concepts are really scientifically unsound.

The Unconscious and Subconscious Ideas.—There may be, in the body, activities which are unconscious; that is, activities which arouse no sensations. Our digestive processes may be going on, active yet unconscious. The seat of consciousness is, of course, the brain and not the stomach. Unless the motor and glandular activities, through sensory nerves, arouse to activity certain neural mechanisms in the brain, the digestive processes arouse no sensations, that is, they do not become conscious. The trouble begins when it is assumed that the sensations from the stomach, even if not experienced as conscious, nevertheless actually exist somewhere, namely, in the unconscious. The fact is that unless they are conscious they do not exist at all—in the subconscious mind, in the brain, or in any other place any more than words exist as things in the vocal organs when these organs are inactive. "Where," it is asked, "is a memory or idea when it is not conscious? Where is the idea of my birthplace when I am not thinking of it? Is it not still a genuine, live idea although not in the region which we call consciousness? Given a chance, will it not leap out of the unconscious into full consciousness? Is this not the process of recollection?" Now this doctrine is as perverse as it is simple. Memories and ideas are not things, which must always exist somewhere. They are merely conscious responses to appropriate stimulation just as movements are muscular responses to stimuli. We do not say that a movement is something actually existing but concealed in a muscle, from which it emerges when activated and to which it returns during inactivity. What we say

is that a mechanism, the muscle, when properly stimulated by means of a nerve impulse, is thrown into action, with a movement as the result. During a period of inactivity, the muscle does not contain an actual movement; all that exisits is the muscle with its nerve connections modified as they have been by past exercise. Likewise, the physical basis of conscious recall is assumed to be a group of cortical mechanisms similarly conditioned by past exercise and thrown into action by stimuli. In sum, an idea, memory, or impulse is like a motor response, in the sense that it is a reaction. It is retained in the same way that an acquired motor act is retained. Neither a movement nor an idea exists as such except when it is activated; at other times, neither exists in the unconscious—it is simply inactive.

Unconscious Impulses.—Impulses to eat, sleep, or dominate are, like movements or ideas, due to reactions of certain mechanisms; and except when the mechanisms are active, the impulses do not exist. The impulse to eat, for example, is produced on occasions by organic conditions such as that of insufficient fuel in the system, or by outer stimuli such as the sight or smell of food, or —best—by both together (summation). Readiness to eat does recur, not by popping out of the unconscious but as a reaction to organic or external stimuli. Similarly, the sex impulses are aroused by certain bodily conditions or by an external stimulus or by both together. Impulses, like memories, are reactions; they exist only when active; at other times there is nothing except the mechanism on which they depend. When not in a state of activity, impulses do not actually exist as entities in the unconscious, in the subconscious, or in the mechanisms which give rise to them any more than snaps and pops exist, as such, in an inactive whip.

These are really not trivial or academic "distinctions without a difference." The Freudians, having gone astray because of the erroneous assumption that every one carries around with him a host of active entities in his unconscious, next assume that these hidden but uncannily active—in fact, intelligent—beings disguise themselves and break out, causing slips of the tongue, dreams, fears, nervous disorders of the various sorts which they find in their patients. There is a tremendous difference between the Freudian statement that the accountant's eye and arm disturbances (mentioned above) are due to the work of active entities from the unconscious and the explanation that these troubles were actually learned in much the same way that the cat learns, after many errors, to pull a string which opens the box in which it is confined.

Conclusions

The various typical ways by which man escapes the annoying situation occasioned by the thwarting of native tendencies, by day-dreaming the activity, by "sour-graping" it, or by pretending that the annoyingness is really satisfying, by rationalizing an excuse for the indulgence, or by substituting some other activity, good or bad—all of these are acquired adjustments. They are learned reactions, just as speaking English, fearing the plague, or cracking nuts are learned reactions or habits. To say that they are learned is by no means to say that they are understood. Just why or how, and often when, he learned to enjoy stories of travel, to whistle, or to count, generally is not understood by the learner, nor does he usually know with any definiteness how he now whistles or counts. The purpose of this chapter has been to present in general terms a number of acquired adjust-

ments to annoying situations provoked by the hampering or thwarting of native tendencies to action; and to illustrate the fact that many habits are formed in the service of the instincts. The detailed processes involved in learning or habit formation remain for later chapters and in none of them will we find it necessary to invoke the use of uncanny subconscious or unconscious entities or mystic powers of any sort.

The "moral" of this chapter is contained in a quotation from William James's famous chapter on Habit: "The hell to be endured hereafter, of which theology tells, is no worse than the hell we make for ourselves in this world by habitually fashioning our characters in the wrong way." . . . "The great thing, then, in all education, is to *make our nervous systems our ally instead of our enemy. . . . We must make automatic and habitual, as early as possible, as many useful actions as we can,* and guard against the growing into ways that are likely to be disadvantageous to us, as we should guard against the plague."

We have stressed mainly the "disadvantageous ways," but the same human capacities to learn may be made to operate in advantageous ways as well. One way to get started right is to make sure you are not started wrong. We should, then, understand as well as we may the tendencies to idle dreaming, self-pity, rationalization, not only in general, but our particular susceptibilities and the conditions under which undesirable reactions are most likely to occur. But mere knowledge of what not to do, indeed, knowledge of just what to do, is insufficient. Habits of holding our mental adjustments within proper limits, of thinking impersonally, of compensating wisely, these in numerous particular forms to meet a multitude of specific difficulties must be acquired.

QUESTIONS AND EXERCISES

1. What instincts are frequently thwarted and what adjustments are often made by the following:

The deaf child
The crippled child
The light-house keeper
The missionary
The slave
The youngest child in a household
The grandmother in a household
The head of a large business concern
The office-boy
The book agent.

2. Are animals more subject to thwarting of impulses than man? Consider the case of the truck horse, and of the uncaptured lion.

3. Were the conditions of life under which primitive man lived more or less conducive to mental health than those of modern times?

4. What are some of the signs by which you can discover in a class of children which individuals are prone to make overt and which to substitute mental adjustments to difficulties?

5. Give five historical examples of individuals who compensated in a useful way for the thwarting of instinctive desires.

6. Explain, in scientific terms, the subconscious.

7. Who is the best judge of whether an individual is rationalizing or reasoning, the subject himself or an observer? What circumstances make different answers to this question possible?

8. Show that the mechanism of rationalization is useful in social intercourse.

9. What mechanism is often behind the use of such terms as "bookworm," "grind," "profiteer" and "demagogue"?

10. Give as many examples as you can of "sour grapes," "projection," and other forms of adjustment. Which do you consider desirable? Which undesirable?

11. We say that a man who resists the prompting of a strong instinctive tendency because it is contrary to the social code, has a "strong will." What do we mean here by the term "will"?

12. List some of the possible causes of eye trouble which prevent the completion of a required task in school.

13. To what mechanism might the normal individual attribute the activities of martyrs and what could easily be the martyrs' reply?

14. Make a list of the excuses frequently given by students failing to pass an examination and examine them for rationalization.

15. Draw up plans for
   (a) a society in which conflicts due to social taboos would be reduced to a minimum;
   (b) an environment in which conflicts due to physical factors would be reduced to a minimum;
   (c) an organism with no conflicting impulses.

How practical are your suggestions?

16. What is the best thing to do when a desire is thwarted?

17. Do the facts presented in this chapter suggest to you any ways in which education may make people more reasonable? more happy? more efficient?

REFERENCES

For a general account of this problem from the point of view of psychology see F. L. Wells, *Mental Adjustments,* 1917, especially Chapters 1, 2, 4, 5, and 8; John Watson, *Psychology,* Chapter 11; R. S. Woodworth, *Dynamic Psychology,* Chapter 7.

The Freudian doctrines are illustrated and explained in Sigmund Freud, *Psychopathology of Everyday Life* (translated by Brill, 1914) and attacked by Knight Dunlap in *Mysticism, Freudianism and Scientific Psychology,* 1920.

James's famous chapter on "Habit," is Chapter 4 of his *Principles of Psychology,* vol. I.

CHAPTER X

THE LAWS OF LEARNING

Acquired activity may be contrasted with inherited, unlearned, native, or instinctive activity, although, as we saw in the last chapter, the two are not independent. Learning would not go on without instinctive drives to activity and, furthermore, learning has its origin in native responses. The simplest form of learning consists in strengthening or weakening of a native reaction. Other forms are merely reorganization of native reactions. All of the skills, for example, which the hand may acquire, are really reorganizations of the native, muscular reaction into new patterns. Here it is the combination or the pattern that is acquired; the elements in the complex are native. Finally, learning itself is a native capacity. It depends upon the inherited modifiability and retentiveness of nervous structure. So that while learned and native, acquired and inherited, habit and instinct, may be contrasted, they are at the same time inseparable.

Learning takes place only during activity; it is never a passive process of absorption but on the contrary a very active process of reacting.

Learning of the observational or informational type, such as becoming familiar with a face, tree, or building so that we can later recall it, or memorizing names and dates, the spelling of a word, of picking up information during reading—these and other sorts of mental acquisitions, like movements and skills, are the results of a

process of reacting. The same is true of learning to control one's temper, or to appreciate music, art, or literature; all are acquired in the process of reacting. In fact, what we learn *is* a reaction; namely, that reaction which, having once been made, is strengthened by use.

The Law of Use

The simplest form of learning consists in the strengthening of native reactions. Exercise of any reaction—walking, grasping, crying, laughing, becoming angry, sad, or joyous—other things being equal, tends to make that reaction more prompt, more certain, more easy. The use or exercise of any situation-response connection strengthens it; the stronger the connection the more prompt, easy, and certain the response. As we saw earlier, the innate capacity to learn is largely a function of the nervous system. The use of a connection unit (series of neurones) brings about certain changes, mainly in the synapses, which makes the passage of the nerve impulse more rapid, easy, and complete. This is what is meant by increasing the strength of the connection between a stimulus and a response. Such modifiability of nervous structure is a native capacity which may be expressed by the *Law of Modification by Exercise,* or, more simply, the *Law of Use.* It may be stated as follows: *Whenever a modifiable connection between a situation and a response is exercised, other things being equal, the strength of that connection is increased.*

The Law of Frequency.—The Law of Use expresses a basal fact, one that is needed to explain learning of every kind. A necessary correlate of this law is the fact that use up to a certain physiological limit is cumulative in effect. If one response strengthens the connection some-

what, then two responses have greater effect than one, three greater than two, and so on. Consequently, other things being equal, the more frequently a connection has been exercised the stronger the connection. This is sometimes called the *Law of Frequency.*

The Law of Disuse

Modifications in the nervous system produced by use, however, are not retained in completeness for unlimited time. The nervous changes brought about by disuse are, roughly speaking, comparable to those produced in a muscle. One may by exercise strengthen the muscle to a high degree of vigor, but the effects gradually disappear with disuse. The gradual forgetting of names, dates, or poetry, the gradual loss of skill in typewriting, drawing, singing, etc., when these functions are not revived by exercise, illustrate this fact. The *Law of Disuse* takes a place with the Law of Use as a well established principle. It may be stated as follows: *When a modifiable connection between a situation and a response is not exercised during a length of time, the strength of the connection is decreased.*

The Law of Recency.—The deteriorations of connections through disuse is a gradual process. One day of disuse causes some loss in the strength of a connection, two days a little more, and so on. The effect is cumulative, a fact often expressed in the correlative *Law of Recency,* which may be stated thus: other things being equal, the more recent the exercise, the stronger the connection between the situation and response.

While the strengthening effect of use is involved in all learning (the weakening effects of disuse being really a passive process), the acquisition of all complex functions

such as writing, speech, swimming, reading, learning poetry, involves a great deal more than mere repetition of a number of native reactions. We do not have a feeble writing ability at the start, which by general exercise is made more easy and secure. We have, rather, a very large number of very minute, specific reactions, each to a particular stimulus, many of which are already organized, loosely or firmly, into acts. In the process of learning, some of these are selected and strengthened by use, others are disentangled and eliminated, to die out by disuse; others, possibly to be killed in some more active way. The acquired act of speaking a word, for example, is a compact bundle of specific connections between minute stimuli and minute reactions, and before the connections are selected, strengthened or weakened and properly fitted together, a tremendous amount of sorting must have been done. In actual learning, then, use and disuse operate upon very minute S-R connections. We do not practice one big writing or speaking reaction as we learn; we select and exercise, with varied vigor and for various lengths of time, hundreds of tiny constituent units.

These facts must be made clear at the outset. So, without bothering at present with explanations of how particular connections are selected or eliminated, we will present a number of illustrations of the facts; first, that learning is decidedly active; second, that it is decidedly specific.

Learning by Reacting

In Motor Acts.—Observe the child learning to say the word "kitty." To begin with, it may be able to make "k" sounds and also "ĭ," "t," and "ē" sounds, but it experiences difficulty in getting them bound together in the way required to say "kitty." During learning, the child

may say a good many things that are more or less close approximations such as "ki," "kik," "kiki," "tiki," etc., and after many trials "kitty." In this simple case, what has been learned is obviously a reaction—a motor reaction—and the process of learning consists in trial after trial, until the proper reaction has been hit upon. Even then, the articulation is far from what it will be a year later; it is merely an approximation. Further improvement follows the elimination of inhibiting reactions—too minute to be identified without knowledge of just what is happening in each and every muscle of the tongue, lips, jaws, and lungs—and the chance selection of favorable reactions, equally minute. The total pattern of the specific reactions when the child speaks "kitty" clearly is quite different from the pattern which earlier produced an approximate "tiki."

The same may be said of all other forms of motor learning—swimming, diving, whittling, writing, handling tools, catching a ball, and so on. We learn during the process of reaction; the big reaction that we can observe is an everchanging complex of smaller reactions.

In acquiring motor reactions, of this there can be no doubt: one learns precisely the reaction that he hits upon. To be sure, each new attempt may produce a different response—quite different often—and for this there are several reasons. A single reaction is insufficient to fix the act permanently. Many of the constituent reactions, never having occurred before, may die out from disuse before the next attempt. The next trial, moreover, introduces new stimuli, as when a boy proceeds to another trial at diving he approaches at slightly different speed, hits the plank at a different place, with legs or arms in a different position, or he may be more timid because of the effect of the preceding attempt. Not only

may the stimuli thus be different, and the reaction to some extent influenced by disuse, but if the interval between trials is long, the complex act as retained in the nervous system may be distorted by the interfering effects of other reactions acquired in the interval.

In Emotional Learning.—What is true of acquired motor activities is true of emotional activities. A child learning to swim at first approaches the water, perhaps, with some trepidation. When the water reaches his knees, he becomes distinctly anxious, showing a tendency to cling to his instructor. Encouraged to wade to his waist, he is seized by a panic of fear. Now, by various devices that good instructors know, he finally goes into deep water with little more than anxiety, and in the course of time with positive delight. When once a desired reaction—a feeling of joy to the water-around-the-body-situation is made, it may be stamped in by further exercise until well learned, so that later it occurs promptly and surely.

While learning to swim, other reactions have been acquired. With reference to water, new impulses or tendencies to action have been learned. On seeing water the impulses to take off the clothes, jump in, and swim, are set up, whereas before, the tendencies were to make a cautious approach, dip in the hands, or wade in the shallow water. New percepts and ideas are also acquired. The feelings of being all submerged in a big body of water, and the memories of these feelings are, of course, learned.

In Acquiring Information.—The fact that our percepts, memories, ideas, information, and conscious reactions of whatever sort are acquired reactions merits special emphasis. However clear it may be that our muscular reactions of swimming and diving are acquired

or that our joys, timidities, and fears secure new attachments as the result of reaction, our perceptions, memories, and ideas are likely to be conceived as the result of passive absorption, or as having just come of themselves. Perhaps one reason is that, under such circumstances, we experience little effort; the learning feels less active—in fact, it may seem to be an entirely passive process. Furthermore, the means by which other people go about motor learning and the actual reactions made are more obvious—at least in the rough—to all. But just how or what other people observe, how or what they can recall, we discover less well. There is something in the ease and subjectivity of these mental acquisitions that leads us to think of them as passive, receptive, incidental, instead of reactions which we make actively. But the fact is that here as elsewhere learning is active and what we learn are the reactions to which we give birth.

Suppose we attempt to discover just what we learn in a particular case. Get a colored picture of a farm-house or any other scene. Invite several others to study it with you for 30 seconds, after which each one is asked to write out a full account; or, better, to attempt to answer a number of questions asked by an additional person holding the picture. It will at once be discovered that no one has mentally photographed the picture; no one finds that the picture has so impressed itself upon him that the details may be seen as if the picture were really there. On the contrary, few can give such details as the number of windows in the house; the number of clouds in the sky, etc. One striking result is that even if all observers recall about equal amounts, which is very unlikely, they have learned different items. Obviously the process of learning, here, is not mere passive impression. The individuals learned, i.e., remembered, only those

items to which they reacted. Occasionally, a listless observer stares at such a picture—the full image of it being formed on his retina—without consciously, actively reacting to it at all, and he may therefore be unable to recall any details, although he may guess a few correctly if the picture is to some extent like pictures he has seen before. Different people learned different things because they reacted in different ways to different items, but without reaction nothing is learned.

How New Reactions Are Acquired

We learn by "hitting upon" a reaction and then exercising it; but how do we "hit upon" the desired reaction? When the child is first given a pencil, he grasps it much as he would seize any small stick; but in the course of time he will have acquired new muscular reactions to this object. How were these new responses achieved? How does it happen that the native or initial reactions, being well established and easy to make, do not continue to occur unerringly? If a child is afraid of thunder, how does he ever get rid of this reaction, since, according to the Law of Use, the more he makes the fear reaction the more firmly it should become fixed. If he does conquer his fear of thunder, what has become of that reaction?

These are important matters that have been deliberately neglected so far; important but very difficult. Nevertheless, we shall have to attempt an explanation, for the practical solution of a good many problems to be encountered later depends upon the answer to the question: How are new reactions acquired?

If we consider some of the purely mechanical features of learning we find that to a considerable extent what we

learn is determined by our environment, by the forces that act upon us. There are, of course, many traits which we acquire that we do not speak of as learned. The sun tans our skin, a disease may enlarge our joints, a knife may cut our flesh, leaving a scar; these are acquired traits but scarcely learned traits. But in a similar mechanical way, the situations which we encounter may modify our *behavior*. Learning is, in fact, often described as adaptation to the environment; and the kind of adaptations made will vary with the features of the environment. We are, however, not passive in the matter; it is by reacting to the environment that new reactions are acquired.

Most of the situations to which we react are very complex, including many specific stimuli in ever changing combination. These stimuli taken singly, or in small units constituting what we shall call *elements of the gross situation,* tend to produce specific effects; that is, each element tends to elicit a specific reaction. The reaction of the body to many stimuli occurring at once forms a complex reaction. Different combinations of stimuli produce different complex reactions and to understand the total we must understand the working of the parts. To be thorough, we should take different stimuli, first one at a time, then two at a time, then three at a time, and so on, until we approximate the kind of gross situations comprising vast numbers of stimuli such as we encounter every day. This, however, will be impossible and unnecessary inasmuch as the principles can be disclosed by taking a simple combination, two stimuli at a time.

Our equipment for explaining learning now consists of the Law of Use (or Frequency), the Law of Disuse (or Recency), and a complex environment which provides specific stimuli in various combinations. We will pro-

ceed to examine representative types of learning, illustrating the way in which these principles operate, going as far as possible without introducing additional laws. If all forms of learning can be explained by use and disuse alone, this will be scientifically desirable because science prefers the simpler to the more complex assumptions. If these principles are insufficient it will be necessary to discover other factors to complete a description of learning.

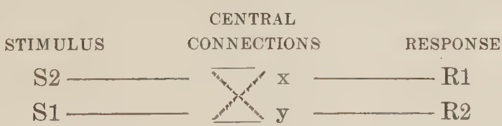
Most of the illustrations are selected from experiments upon animals, partly because these are more available, partly because the behavior of animals, being more simple, is easier to describe.

The Association of Simultaneous Reactions

New connections are established when two (or more) stimuli which elicit different but not mutually exclusive reactions are repeatedly presented simultaneously. When an object moves rapidly toward the eye, the native reaction is a wink; when the skin of the finger is stimulated with a slight electric shock, the native response is a quick withdrawal of the hand. If the two stimuli are given at once the result is a simultaneous wink and jerk of the hand. If we continue, time after time, to give the two stimuli at once and finally give only one—say the electric shock—the probable result is that both the jerk of the hand and the wink will occur at once. Or, if we move the object rapidly toward the eye, both wink and jerk will occur. Here, then, is a clear case of acquisition; we now have a combination of two responses to a stimulus which previously gave us only one. Or, to say the same thing in another way, we have acquired new connections: one between the eye stimulus and the hand effectors, and

another between the hand stimulus and the wink mechanism. New pathways through the nervous system have been opened up and strengthened by use (repetition) so that the nerve impulse flows through and produces effectively a new reaction.

A significant feature of the nervous system is that it provides pathways from each receptor to a tremendous number, very likely, to all effectors (see pp. 56 f.). Of these innumerable connections but few are strong enough to arouse the effectors as the result of ordinary stimulation; the others are 'closed' in the sense of ordinarily producing no observable reaction. So that in reality, physical connections between the eye stimulus and the hand muscles, as well as between the hand stimulus and the eyelid muscles must have been in existence to begin with. Let us call the stimulus, movement of the object toward the eye, S1 and the wink R1; the electric shock S2 and the withdrawal of the hand R2. The connections are pictured in the figure below. The heavy line indicates



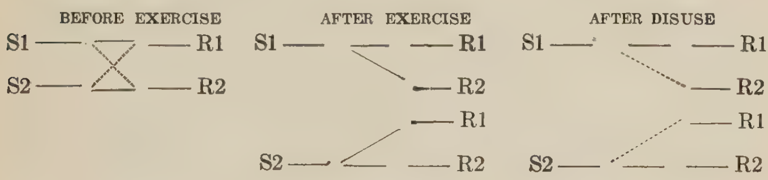
a strong connection, the dash line a weak connection. Although S1 is actually connected with R2 it cannot alone arouse R2 because the intervening pathway (mainly the synapses at y) offers too much resistance. When S2 is stimulated at the same time, the barriers at y are broken down so that the impulse from S1 gets through, discharging weakly, at first, into R2, according to the principle of facilitation (see page 59). By repetition of this combined stimulation, the impulse from S1, according to the Law of Use, would break through more and more readily.

In other words, the connection between S1 and R2 is gradually strengthened by use until S1 alone is capable of producing the response R2 as well as its original, R1. All of this is true of the S2-R1 connection also.

By the repeated association of two stimuli which produce two harmonious (in the sense that both can occur at once) reactions, each stimulus becomes connected with both responses. To each has been attached a new reaction, in addition to the old one. The object-approaching-the-eye produces a jerk of the hand; the shock produces a wink. Neither of these was made, until the "subliminal" connection (a connection too weak to elicit an actual response) had been strengthened by the combined exercise. Thereafter, either stimulus produces both responses; and according to the Law of Use, continually to administer one stimulus would further increase the strength of both connections, so that the combined response would occur more surely, promptly and easily. This raises the question as to whether both combinations are identical. No, they are not; for the reason that the connection of each stimulus with its old response always remains stronger. The object-approach-eye stimulus invariably produces a combination in which the wink is more emphatic; the finger shock produces a combination in which the finger jerk is more pronounced. While the reactions in both cases include both wink and finger jerk, it is necessary to think of them as a *joint reaction* determined by the strength of the particular connections between the specific stimuli and the specific responses. The justification for this is seen most clearly if you fail to exercise one of the joint reactions for a while. Fail to apply the shock stimulus for a time and the wink unit of the combination may fail to occur,—it has died out from disuse,—whereas the withdrawal of the

hand, being more strongly connected with the stimulus, still occurs.

The facts may be shown diagrammatically in the accompanying figure.



In the figure the heavier the line the stronger is the connection. The dotted line means a subliminal connection.

Association of Motor Reactions.—When a hungry kitten sees food it will run toward it. If a child displays food, at the same time calling "Kitty, kitty," a sufficient number of times, the kitten will eventually respond to the call alone. When we are breaking a horse, it does not, of course, respond in any way except by pricking up its ears when we say "Whoa." We stop the horse by pulling on the bit and if, at the same time, we shout "Whoa," and repeat sufficiently, the horse will stop eventually at the word. In both of these cases new connections have been acquired. In both cases, the old response to "Kitty, kitty" or to "Whoa" was mainly an awareness of the sound with but little motor response. These responses still persist but occur simultaneously with the new reactions, i.e., running toward the call or stopping at "Whoa."

Association of Emotional Reactions.—Connections with glandular reactions, as well as with motor reactions, may be acquired in this way. To the stimulus, food in the mouth, a dog responds by secretion of saliva. If at the time food is presented a bell is rung, the animal will, after sufficient trials, respond by the salivary reaction to

the bell alone. It is in this way that the human mouth comes to "water" at the sight or smell of food, the sound of the dishes or the dinner bell, or the mere thought of food. Very diffuse organic or emotional reactions may be attached to new stimuli in this way. A man who suffered acute nausea in a room which smelled strongly of camphor finds that later the odor of camphor tends to reinstate the sickness. After a long voyage, during which one has been seasick, the smell of ship or sea or the mere thought of them may turn one's stomach in some degree. Similarly tears, mirth, affection, or minor likes and dislikes may secure new attachments. In these instances, the reaction produced by the newly attached stimulus is not identical with the response produced by the original. It is merely a weakly aroused reaction of the same sort; weakly aroused since it would require a great deal of exercise to make the new connection as strong as the old.

Association in Informational Learning.—Certain types of information are acquired by attachments of this sort. When shown a leaf, the child reacts by becoming aware of the object. If, while showing the object, one says the word "leaf" a number of times, the child will, at length, think of the object when he hears the word alone. Thus he learns the meaning of the spoken word; for the word itself is merely a combination of auditory stimuli, of course, not in the least like the visual appearance of a leaf. Next, we may show the object (or say "leaf") while the child looks at the printed word "*leaf*." With sufficient combined repetition, the child now thinks of the object when he sees the printed word. Later the object, a picture of the object, the spoken, written or printed word, may be coupled with the French word "*la feuille*" and the two together reacted to until he thinks

of the object or, at least, something which stands for the object, when he sees the French word.

Association in Perception.—In actual life, the simultaneous stimuli are not invariably limited to two; indeed, the usual case includes many more, but the principle is the same. It is by the combination of many reactions, for example, that percepts are built up. When a child is first given an apple he makes a good many reactions to the many stimuli which the fruit provides. He becomes aware of its odor, of its color, of its shape, its weight, and its taste by responding to the several olfactory, visual and other stimuli, simultaneously or in immediate succession. The several responses become attached to each of the several stimuli and with frequent repetition of the experiences, one stimulus alone may activate simultaneously, *to some degree,* the several reactions. The apple is thus perceived when only seen or smelled or felt. We become at once aware of it as a combination of such and such tastes, odors, shape, weight, etc. An apple perceived through the sense of touch is not exactly the same as the percept of an apple smelled, tasted or seen. But the perceptual reaction is so quick, and our interest in it so practical, generally, that we do not observe the fine differences. We simply become aware of an apple, neglecting the sensory and other minor details.

The samples of learning so far considered are, of course, acquired by use, once the possibility of the exercise of the new connection is established. The inter-connections in the nervous system make possible limitless additions of connection; all that is needed, apparently, is simultaneous presentation and exercise. If we can attach the wink reaction to a stimulus on the finger or the salivary reaction to the sound of a bell, it would appear that we can attach any stimulus to any response. So we

may generalize: *by means of association and exercise any reaction which the organism can make may be attached to any stimulus to which the organism is sensitive.*

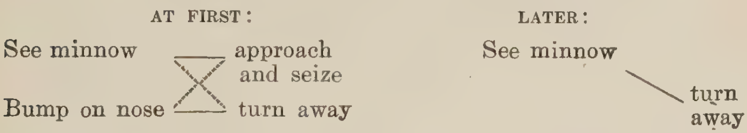
This is an important generalization but should it be called a law and be put on a par with the Law of Use or Disuse? If we examine the facts closely it will appear that exercise is really doing the work. From the start there existed real but weak (subliminal) connections which were strengthened when the proper combination of the stimuli was provided. We have merely described the results of the operation of the Law of Use under certain conditions; namely, when two (or more) stimuli leading to different but not mutually exclusive reactions are repeatedly presented together.

The Elimination of Connections by Simultaneous Association

Learning does not consist entirely of addition or strengthening of connections. Elimination or weakening of connections already present is quite as important. A reaction may be eliminated by the simultaneous presentation of two (or more) stimuli which lead to mutually exclusive reactions.

An Experiment with a Perch.—A minnow thrown into an aquarium with a hungry perch will be very promptly seized, since the former acts as a stimulus to one of the strongest of the latter's native food-getting reactions. If a glass partition is placed dividing the aquarium into halves, the perch in attempting to seize a minnow thrown into the opposite compartment bumps into the transparent obstruction. On receiving the bump, the big fish turns about and swims to the edge of its compartment.

Shortly, it darts at the minnow again only to be halted by the same punishment. It will suffer a good many bumps on the first day before giving up entirely, but on the next day fewer bumps are effective; and so on, until after thirty days, when the minnow is thrown in, instead of attacking, the perch swims off to the side or engages in other activity. The attack reaction has been, temporarily at least, eliminated. The bump not only blocked the old reaction but set up a turn-about-and-swim-away reaction which by simultaneous association became attached to the old stimulus. When the perch now sees a minnow, the nerve impulse is shifted into the turn-away reaction. This may be shown in a diagram.



An Experiment with an Infant.—An infant while playing with some pets, which it fondled with pleasure, was frightened by a crashing noise. The child, of course, could not fondle the pets and at the same time withdraw in fear. The fear reaction, getting the right of way, put a stop to the caressing of the animal. The interesting thing about this case was that later when the child saw one of the pets he no longer approached it with pleasure but retreated in fear. This was not a combination of two reactions, but a selection of one reaction and elimination of the other. The nerve impulse aroused by the sight of the animal has been shifted from its old course into another. The fear has been substituted for the fondling reaction. So far as the mechanism of association is concerned, this case is quite like the previous one, as shown in the accompanying diagram.

BEFORE EXERCISE:		AFTER EXERCISE:	
See pets	approach and fondle	See pets	
Hear noise	retreat in fear		retreat in fear

The elimination of the attack on the minnow by the perch might be explained by the simultaneous introduction of a stimulus (the bump from the glass partition) which proves an effective block and which also sets up a mutually exclusive or "incongruous" reaction—the turn-away. In the case of the child who acquired a fear-and-retreat reaction on sight of the animals, there is scarcely a blocking of the original response of approach, although there is introduced an "incongruous" reaction. That is, the child cannot simultaneously approach-to-caress and withdraw in fear. The latter reaction wins out conceivably because it is stronger and by means of association becomes attached to the stimulus which originally led to the incompatible response of approaching-to-fondle.

Elimination without a Blocking.—Responses are eliminated, however, when no block or obstruction or other stimulus is present to set up an incongruous reaction. A famous experiment, performed by G. W. and E. G. Peckham, will serve as an illustration: These observers found that a spider dropped hurriedly from its web at the sound of a tuning fork. When it had climbed back, a repetition of the stimulus produced the same dropping reaction; but after eight or nine trials the stimulus suddenly lost its power; the spider failed to react by dropping from the web. Next day, however, the stimulus was effective for a time but failed after six or seven repetitions, and after about ten days the dropping reaction ceased entirely—at least for a time. In this experiment the spider's reaction was in no way blocked; no pain was involved; no

definite incongruous reaction was set up. The connection between the sound of the tuning fork and the response of dropping, which was at first prompt and certain, had been gradually stamped out.

Limitations of the Laws of Use and Disuse

This is really a most curious matter. The dropping-to-the-ground reaction had been eliminated in the very process of exercise. According to the Law of Use, the tendency to drop at the sound of the tuning fork should have been strengthened; should have become more prompt and certain. Instead of that, it gradually became less prompt and certain, finally being eliminated entirely.

This phenomenon might well bring the Law of Use under serious suspicion. This experiment, however, does not discredit the Law of Use but portrays one of its limitations. Exercise is a true and faithful servant of learning, but it is unable to do all the work alone. In fact, all along we have been neglecting another and possibly more powerful factor, one which we must shortly bring forward. Before so doing, it will be advisable to present a few more illustrations of the inadequacy of the Laws of Use and Disuse, in which the new factors, which contribute to the control of learning, are more clearly portrayed.

For one investigation, a box was constructed in such a way as to offer to a rat placed in a certain compartment four different avenues of escape, all of which led to food. The box is pictured in Figure 22. One way led through a small compartment in which the rat always received a slight electric shock as he passed; a second led to a similar compartment, in which the rat was confined for twenty

seconds before being permitted to proceed; a third led to a long pathway to be traversed before food was reached; and the fourth compartment provided a short pathway directly to the food. The positions of the four little

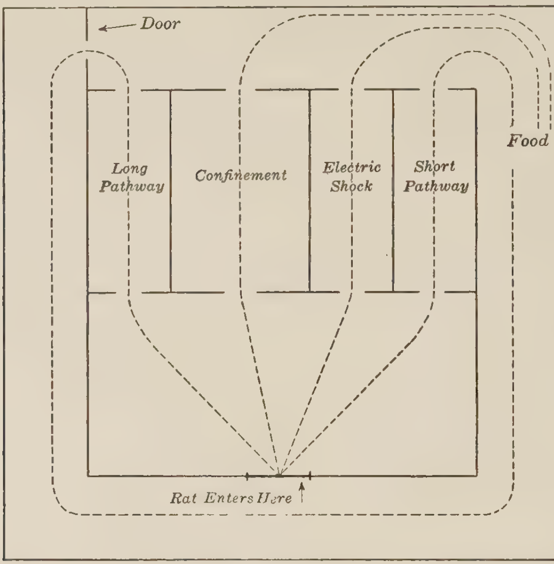


FIGURE 22. The experimental compartment box showing the several routes. In the actual experiment the compartments were rearranged for different groups of rats, *e.g.*, for one group "confinement" would be situated on the left, for another in the second position, as pictured above, for another in the third position and for another on the right. Thus no type of "effect" was given the conceivable advantage of a favorable position. Movable doors were also provided to force the rat in the direction desired after emerging from the compartment. (After Kuo. *Journal of Comparative Psychology,* Feb., 1922.)

compartments were so arranged that a particular rat, on his first trial, was as likely to enter one as another; so, by using a number of rats, it was possible to ascertain the factors which guided choice. Each of thirteen rats was given trials until it had finally selected and thoroughly learned one of the four ways.

At first, a rat was as likely to take one way as another, with the result that in the first four trials each way to the food was practised equally often, approximately. But soon all had given up the pathway which produced the shock. A little later all had refused the way which produced the twenty seconds of confinement. The long way was eliminated more slowly; but finally all but two went by the short route. Now, by the Law of Use alone, an equal number should have learned permanently to go by each route, since each was chosen and exercised equally often at the beginning. But the fact was that the exercise which brought pain failed to be effective; the rats soon gave up that route. Practice of the trip which brought confinement was more effective; but finally that route was eliminated by the whole group. Use of the round-about pathway was likewise insufficiently effective, since with the exception of two rats all gave it up, although they relinquished this pathway less promptly than they did the first two routes.

Another illustration, similar in principle, may be more clear. Suppose that after five cats have been taught to come to the call of "Kitty, kitty," each is called singly, and No. 1 is given food and later caressed, No. 2 is caressed only, No. 3 is totally disregarded, No. 4 is sprinkled gently with water, and No. 5 is douched with water. Assuming that all have just learned to respond to the call and that other conditions such as hunger, fatigue, the satisfaction occasioned by the activity under way at the time called, etc., are approximately equal, they should all learn to come more promptly and surely by virtue of exercise, as they are repeatedly called. But will they? Cat No. 1, which was fed and petted, will probably come more and more surely and promptly; No. 2, which was merely petted, will probably continue to

come but not so promptly as No. 1; No. 3, which was entirely disregarded, will probably continue to respond for a while, but less promptly and frequently, finally failing altogether; No. 4, which was sprinkled, will probably give it up more quickly than No. 3; and No. 5, which was douched, will probably very promptly show a failure to respond.

The Influence of the Effect of a Reaction.—There is no doubt about it: influences other than exercise are at work here. Very potent influences they must be to nullify and augment the results of exercise as they do in the illustrations just given. Apparently there is something about the *effect* which accompanies or follows an act that either reinforces or decreases the results of use or causes an animal to repeat the act in one case and avoid it in the other, or both. Pain, confinement, the holding up of a tendency under way, futile or wasteful work all tend to stamp out the reactions which they accompany or follow. On the other hand, reactions which bring release from confinement or pain, which bring food, kindly treatment, or attention, are repeated and stamped in more rapidly than when they are exercised with an indifferent result. It is the reaction which brings, broadly speaking, a satisfying state of affairs, absolute or relative, that is repeated and stamped in quickly during use. The more satisfying the resulting state the more surely the reaction will be repeated and the more quickly stamped in. On the other hand, those reactions which are avoided or are stamped out even during the process of exercise, are the ones which are accompanied or followed by annoying states of affairs or annoying effects.

It is upon such experiments as these, among others, that the concept of the satisfying and annoying states of affairs, as dynamic factors in determining behavior is

based. General statements of this concept have already been given and to these the reader may refer.[1]

The fact that human beings as well as animals tend to repeat those reactions which, broadly speaking, bring a satisfying state of affairs, and that such reactions are stamped in very rapidly, whereas they tend to avoid, and fail to repeat those reactions which bring an annoying state of affairs and that such reactions are soon stamped out, might be illustrated at length.

An infant lying in its crib is disregarded by its mother and her guest. Soon the child begins to cry and scream. The women rush to the baby, pick it up, fondle and pet it. Treatment highly satisfying to the child is thus associated with crying and screaming. Similar experiences follow on many occasions, and when the child has attained several years of age it still sets up a great racket if it is disregarded or uncomfortable. The tendency to cry and scream in such situations had been built up by the satisfaction of attention which it had always brought. One child, age eight, had developed a habit of persistent "begging" when its mother said "No" to its requests, whereas a neighboring child of the same age took "No" as final without further whining or whimpering. Both had in earlier years repeated their demands after the first "No," but the mother of the first child, perhaps to avoid being bothered, frequently gave consent sooner or later, whereas the other mother did not change her decision. A child learned to use a "naughty" word on the street because it was taught and applauded by some "nice big boys," but its use at home was stamped out because it brought a scolding, or perhaps better, total disregard. Attach satisfaction to any response and it will be learned; attach annoyance and it will drop out.

[1] See pp. 151-154.

The Law of Effect

We now need a general statement to cover the observed facts concerning the influence of the effects of a response upon the individual's future behavior. We need one or more generalizations that will embrace the facts in a simple yet faithful way. The following statement seems to be satisfactory: *The individual tends to repeat and learn quickly those reactions which are accompanied or followed by a satisfying state of affairs. The individual tends not to repeat or learn quickly those reactions which are accompanied or followed by an annoying state of affairs.* These statements constitute the Law of Effect.

The influence of the satisfying or annoying state of affairs may be that of a selective agent. When the individual is annoyed by a reaction, he tends to avoid that reaction in the future and consequently does not acquire the reaction through exercise. When the individual is satisfied, he is attracted rather than repelled by the stimulus; he tends to repeat the same reaction which is consequently stamped in or learned. It may be that the satisfying and annoying states of affairs exert their influence entirely by way of the general orientation to approach-and-repeat in the one case and to avoid in the other.

Thorndike, in his pioneer work on animal learning, was led to ascribe more far-reaching effects to satisfaction and annoyance than a mere general orientation or selective tendency. He was inclined to believe that "satisfyingness" and "annoyingness" were intimately associated with the subtle changes in the neurones themselves, which in one case intensify or further the effects of exercise and in the other reduce or nullify them. These hypotheses are contained in the following quotation: "When

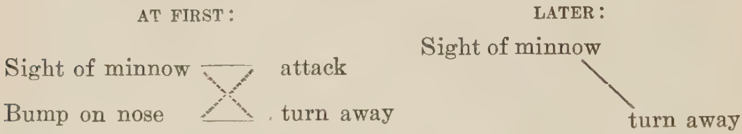
a modifiable connection between a situation and a response is made and is accompanied or followed by a satisfying state of affairs, its strength is increased: when made and accompanied or followed by an annoying state of affairs, its strength is decreased." That is, the *effects* of exercise influence the neurones in the one case in a way favorable to strengthening the connections and in the other case in a way to weaken the connections. Just what the inner results of satisfyingness and annoyingness are is not as yet known. This fact cannot be urged against the theory, however, since there is similar lack of information concerning the neural changes brought about by use and disuse, whose efficacy is universally admitted.

While the precise mode of operation of satisfying and annoying states of affairs or effects is not known, there can be no doubt about the validity and necessity of the first generalization, namely, that individuals tend to repeat and learn quickly those reactions which are accompanied or followed by satisfaction; and they tend not to repeat those reactions which are accompanied or followed by annoying states of affairs. The effect of a reaction thus tends to determine what connections are acquired or eliminated.

Applications of the Law of Effect

A little more attention must be given to the matter of elimination of connections, now that we have the Law of Effect to apply, because it has some important implications for learning, particularly when we are dealing with very strong tendencies. Let us recall the experiment with the perch. When the perch received the bump on the nose he turned about and swam away. The annoying effect of the bump weakened the tendency to attack

until finally, when the perch observed a minnow he turned away instead of attacking as before. The turn-away reaction has been substituted for attack, as shown in the accompanying diagram.



What happens to the old reaction—that of attacking a minnow when it is seen? Since it is no longer being exercised, it is of course dying out, according to the Law of Disuse. But so strong a tendency as that of a fish to seize its food takes a long time to die out from mere disuse. Many acquired reactions, which are probably less deeply imbedded in our nervous system, will scarcely die out from disuse in the course of a lifetime. If you could, by some miracle, refrain from saying, thinking, or otherwise using your name, how long would it be before recall would be impossible? Certainly a very long time, probably more than fifty years. So the perch's tendency to seize minnows is still in existence but, for the present, another reaction is taking its place, namely, the tendency to turn away—a reaction originally made to the bump on the nose but now made directly to the presence of the minnow. How long will this substitute reaction keep up? Just so long as it remains stronger than the other tendency. But actually in this experiment the perch gradually lost the turning-away reaction and went back to his old trick of seizing the minnows. Why? Because the substitute reaction, although exercised, produces no satisfying effect. On the contrary, it becomes annoying and thus its strength is reduced until the old reaction gets the upper hand.

These facts may be illustrated by observation of human behavior. A child is natively self-assertive—so forward and boastful that the parent in an attempt to break his tendency demands, on each outbreak, that the child sit quietly and silently for five minutes. After this has been done several times, the situation which previously elicited a boastful outbreak now tends to produce cautious remarks, because of the effect of the earlier punishment. With no outbreaks, of course, goes no further punishment and as time goes on, the holding in of the impulse to boasting becomes annoying, which steadily weakens the acquired reaction until finally the old reaction breaks out again. One cure for it is further punishment; but there is another way of dealing with the situation, namely, by making the substitute reaction satisfying.

If the perch, when it turned toward the side of the aquarium after the bump, had been given food and similarly rewarded on each succeeding instance, it would eventually, on seeing a minnow, promptly turn to the side where it was fed. If the child had been greatly satisfied by praise or some other reward whenever it refrained from unseemly self-assertion, the more modest reaction would have been gradually built up through exercise and effect where exercise alone might have failed. Here then is the essence of eliminating undesirable tendencies; start the desirable substitute reaction somehow, by punishment if necessary, but build it up by making it satisfying.

Social disapproval, harmless deprivations, and other annoyers may do as well as punishment. Any stimulus that will elicit the desired substitute reaction is what is needed. For example, in attempting to "break" the child of fear and crying during thunderstorms, scolding, threats, or other punishments only make matters worse. Show an interest in the lightning, call attention to its

novelty and beauty and thus substitute for the undesirable reactions curious observation. When you get that, or some better substitute, reward it by praise. It is thus by the proper manipulation of satisfyers and annoyers as well as by practice that the course of learning may be most effectively directed.

Two additional facts should be taken into account in utilizing satisfiers and annoyers. The first is that the effects of either become greater the more closely it is associated with the reaction in time. To be really effective, satisfiers and annoyers must accompany the reaction or at least follow it promptly. If long delayed they may be ineffective or they may become attached to an entirely different reaction. The second fact is that satisfiers and annoyers differ in degree or intensity and that the greater the intensity up to a certain limit, the greater the effect of learning. Food for a hungry cat is a more intense satisfier than petting; a bucket of water dashed on a cat is a more intense annoyer than a sprinkling. What states of affairs satisfy and what annoy human individuals was disclosed in a measure in the studies of the original nature of man.

Summary

1. Exercise always means reacting.

2. Other things being equal, when a reaction is made to a stimulus the strength of the connection is increased. The increased strength is due to modification of the mechanisms — mainly the neurones involved. Increased strength of a connection makes the response more easy, prompt, and certain. This is the Law of Use.

3. Other things being equal, a period of disuse results in the weakening of the connection between the stimulus and the response. This is the Law of Disuse.

4. Reactions which are accompanied or followed by a satisfying state of affairs are more likely to be repeated and, consequently, learned. It is possible also that satisfying exercise strengthens the connection more rapidly than exercise alone. Reactions which are accompanied or followed by an annoying state of affairs are unlikely to be repeated and, consequently, unlikely to be learned. It is probable, moreover, that annoyingness tends to directly weaken the strength of connections, and thus to eliminate reactions.

5. New S-R connections may be formed when two (or more) stimuli which elicit two (or more) compatible reactions are repeatedly given simultaneously. This is possible because exercise and effect strengthen connections that were already in existence but were too weak to operate. Each stimulus may now produce both reactions, each with a degree of certainty and vigor that is dependent upon the strength of the particular connections.

6. Annoyingness may result in the elimination of one or more existing connections. Thus, a cat which has learned to come to the call of "Kitty, kitty," will eventually fail to respond if it is punished or disregarded when it does come.

7. A connection may be mechanically eliminated (at least temporarily) when two stimuli, which lead to mutually exclusive reactions, are repeatedly given together. Thus a retreat reaction, which is set up when the perch, attacking a minnow, is bumped on the nose, may become attached to the old stimulus. Whether such a substitute reaction persists or not depends upon further exercise and effect.

8. The most effective way of eliminating an undesirable response is to set up somehow a desirable substitute

which, to be perpetuated, must be made more satisfying than the original undesirable reaction.

QUESTIONS AND EXERCISES

1. Using the summary of the chapter as an outline, fill in from memory as much of the concrete evidence as you can.

2. In what respects does the substance of the chapter constitute an enlargement of the statement "We learn by doing?"

3. Compare the activities of a child learning to say "kitty" with those of a man trying to avoid some painful state of affairs, as described in Chapter IX.

4. Give some illustrations of the attachment of a new stimulus to a response by association. Diagram it.

5. Give some examples from everyday life of the detachment of a reaction from its stimulus produced by an annoying effect.

6. Give instances of teaching children in school or at home in which the law of effect is ineffectively used or neglected or cases in which bad impulses are actually rewarded.

7. What, primarily, determines what shall satisfy and what shall annoy?

8. Can you give cases where punishment for poor school work has led to a dislike for that school function or for school work in general?

9. What rewards does the school usually give for successfully spelling or reading words? What better ones can you suggest?

10. Apply the Law of Effect to the grading, return, and display of examination papers. Should papers be returned promptly? Should you emphasize errors only? Should you expect perfection and take it for granted without commenting on it? Should you list the names of the 10 best or the 10 poorest pupils?

11. How should you proceed to help someone break the habit of smoking? Pitying himself? Getting the "blues"?

12. What might be the effect of punishing a child by making him stay in after school to write all misspelled words 20 times each?

13. Defend or criticise this statement: "The Law of Effect is the most important law of learning."

14. How would you explain learning to disregard the noises in

a school room, impulses to play during working hours, or the tendency to feel "hurt" when criticised?

15. If there were no Law of Effect would the learning of a child be more or less at the mercy of his environment? In what ways would we have to change our methods of teaching?

16. If it were not possible to strengthen new connections by simultaneous association, could any learning take place?

17. Are capacities to learn native or acquired?

REFERENCES

William James, *Psychology, Briefer Course,* Chapter 26.

E. L. Thorndike, *Educational Psychology, Briefer Course,* 1914, Chapters 10 and 11.

R. S. Woodworth, *Psychology,* Chapter 16.

CHAPTER XI

GENERAL CHARACTERISTICS OF LEARNING IN COMPLEX FUNCTIONS

Learning, as we observed in the preceding chapter, consists in the strengthening and weakening of connections between situations and responses. When two or more stimuli operate at once, new connections may be formed in the sense of being strengthened from subliminal to functioning strength by means of exercise and effect, and old connections may be eliminated in the sense of being weakened until incapable of operation, or in the sense of being supplanted by new connections attached to the same situation. In general, then, all learning may be said to consist in the addition and subtraction of working S-R connections. The acquisition of any new complex reaction is the result of a great many additions and subtractions of connections, and each change is brought about in the ways illustrated in the preceding chapter.

Several conditions are needed to provide a typical illustration of complex learning. First, there must be some stimulus to arouse the organism to activity. The stimulus must either produce an annoying situation which the animal attempts to avoid (hunger or confinement would be a sample) or a state of readiness for or impulsion toward some consummatory reaction. Thus the presence of food might arouse an impulsion to reach for it and eat. These conditions are necessary, otherwise the animal would settle down comfortably with the result

that nothing is learned. Second, the animal must be confronted by a complex situation comprising many features (or stimuli) to which it may react. Third, the successful reactions, in the typical case of complex learning, must be not as yet habituated. With these conditions fulfilled, the operations of the Laws of Exercise and Effect may be observed, resulting, as they may, in the weakening or elimination of certain connections, the selection and strengthening of others and the combination of responses into various types of combined reactions.

In this chapter, several types of learning will be illustrated with some attention given to their similarities and differences; the learning of animals will be compared with that of man; and the amount, rate, limit, and permanence of learning will be treated in a general way.

Trial and Error in Learning

Learning the Way through a Maze.—If an animal can learn at all, it can learn its "way about." A maze, consequently, is a useful device for studying learning. By using labyrinths of varied difficulty it is possible to get a rough measure of the learning capacity of different species.

Ordinarily, mere confinement in a maze is sufficient to arouse the animal to activity but usually food is added as an incentive; the animal is rewarded by finding food at the end of the correct course.

A worm, a small chick, or a turtle can master a simple maze; but a rat, which is able to learn fairly complex pathways, is more frequently used in experimental work. Placed in a maze, as shown in Figure 23, the rat begins to nose about cautiously. He explores here and there, sniffing at everything as he goes. A human subject would

study the features encountered, with his eyes rather than his nose. After going into a blind alley, the rat explores it thoroughly before coming out. If it receives a slight electric shock on reaching the terminus of certain blind alleys, it scampers out and very likely moves on or possibly retraces its steps to the more familiar territory al-

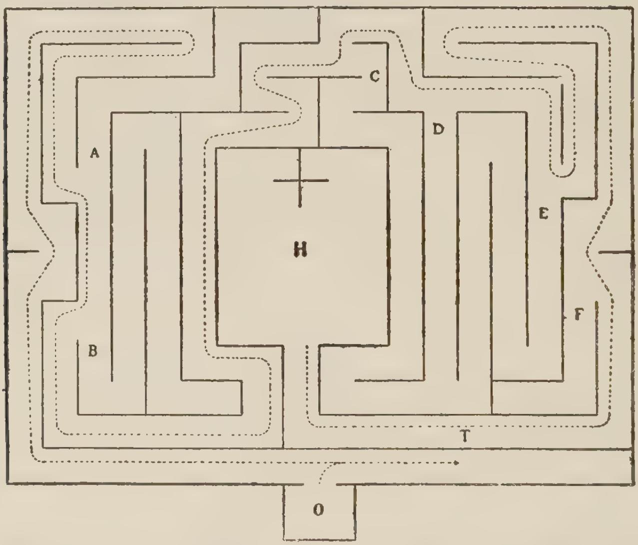


FIGURE 23. The Hampton Court Maze which is frequently used to study the learning of rats. The animal is admitted at *O*. Food is placed at *H*. The dotted line indicates the direct pathway. *A, B, C, D, E, F* indicate blind alleys. (From Watson's *Behavior*, p. 103.)

ready covered. After a time, it will venture again, and perhaps after many errors eventually finds its way through the maze to the food box. During a second trial, the rat works its way through the maze cautiously as before, but with fewer entrances into blind alleys, especially those wherein the shocks were experienced. It takes many trials, the number depending in part on the complexity of the maze, before the rat, by a gradual process

of elimination of annoying errors and acquisition of satisfying correct reactions, is able to follow the proper course unerringly. The rat has now acquired a series of reactions which with reference to the features of the maze situation are new. So far as one can observe, the learning process consists of: (1) the making of reactions, native or previously acquired, to the features of the situation, i.e., old reactions which constitute the "trials"; (2) the gradual elimination of the annoying errors, i.e., the old or trial reactions which bring painful shocks or which end in failure to relieve the confinement; (3) the gradual stamping in of the reactions which were satisfying because they furthered the animal's progress toward escaping confinement and reaching food; and (4) the linking together of the various successful reactions into what appears to be essentially a unit, embracing all of the several steps or constituent reactions.

An outstanding characteristic of such learning is the great number of "trial" reactions and the numerous "errors" which occur before the animal hits upon the successful responses. The animal at first makes an enormous number of reactions, and the process of elimination and selection is gradual. Even when the correct series of steps have been made, trial and error are still found, sometimes of a sort too subtle to be readily observed. Tiny errors are still being made and eliminated; very minute improvements are constantly being achieved. The progress of learning is not steady; the number of errors made or the amount of time taken gives a zigzag *curve of learning* as illustrated in Figure 24. This type of learning is described as *"trial, error and success"* or, more frequently, *"trial and error"* learning.

How Human Subjects Learn a Maze.—If a college student is given a maze to solve which is as difficult for

his species as the one described is for rats, the general process of learning will be the same. Hunger or annoyance at confinement may not be required to arouse his activity and thus make learning possible, but some motive—the desire to accomplish something, to learn something, to display ability, to get through with a prescribed experiment—must be invoked. Once under way, the student proceeds until an error is made, whereupon he retraces his steps and goes ahead again. If he receives an electric shock in some blind alley, he, like the rat, is likely to eliminate that error early. When he has completed the maze, several more trials are required to establish the new, successful reactions firmly. The general features of the learning of men and rats are thus the same; only in certain particulars do differences appear.

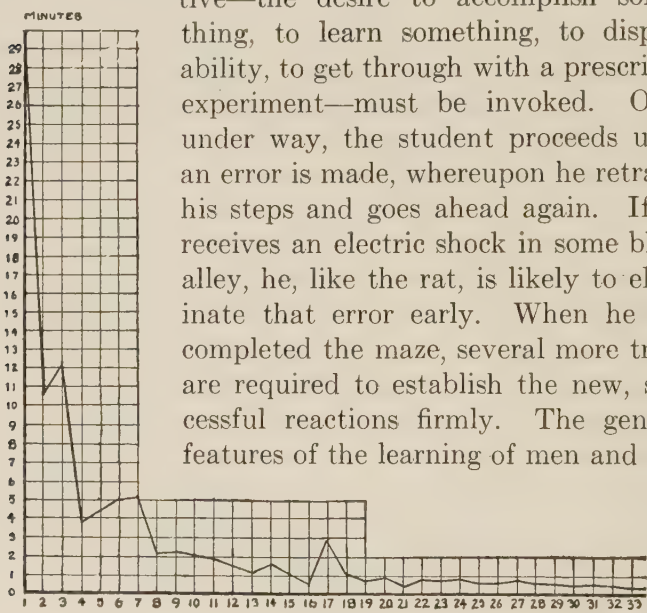


FIGURE 24. A curve of learning the Hampton Court Maze (shown in Figure 23) based on records from four rats. The vertical column of figures at the left indicate the time required for the trials which are numbered along the base of the figure. (From Watson's *Behavior*, p. 211.)

The human learner makes good use of his vision, in which he is superior to the rat. If the human learner is blindfolded, he is tremendously handicapped. Man probably has some advantage in the modifiability and retentiveness of his nervous system, that is, any reaction

made has a greater effect; it is "stamped in" or "stamped out" more readily. If he notices a sign on the right way or gets a shock in the blind alley, these experiences are retained better. The human learner also indulges to a greater extent in mental activity. By means of memory, he can represent or recall some of the situations and the responses which he made to them. Arriving at an intersection of paths, some sign—the look of the place—may enable him to recall the alley and what he did in it at the last trial. Man, more than the animal or even the child, stands at the crossway and contemplates, and thus often saves energy, time, and errors. The animal and the child keep on the move and usually make more errors. But the "memories" or "ideas" of the man add nothing to the general character of the process. They are trials and may lead to error or success, just as the animal's actual movements do. The "ideas" are merely substitutes for actual observation and movement.

Types of Mental Activities Involved in Learning a Maze.—How many and what types of activity are involved in learning the way through a maze? Does it involve motor learning? Is it a case of acquiring muscular skill? Yes, it certainly involves the formation of motor habits. "Skill," as generally used, is a broad term which includes essentially all forms of motor learning; so our answer is "yes" to both questions. Could it be said that learning a maze involves perception or observation? Are percepts built up? Yes, indeed. The good use of visual perception, by man at least, is an essential feature. If the problem is a "pencil maze" to be learned while blindfolded, tactual percepts are important. A blind man, more experienced in tactual learning, would have some advantage here, whereas in a large maze, lacking vision, he would be at some disadvantage; but here he would

make good use of auditory perception, detecting walls and open and closed alleys, for example, by interpreting the echo of his footsteps. A rat would use olfactory perception more than humans do, thus detecting traces of his previous course, unless the scent has been carefully washed out by the experimenter. Does learning a maze involve memory? Again, yes. Memory is merely a name for one form of retention, namely, the retention of things and events observed or perceived. We may profit by remembering or recalling the circumstances attending previous trials. Does learning a maze involve reasoning? Yes, it may. Reasoning, in fact, is trial-and-error learning and as the term is ordinarily used it refers to the manipulation of or exploration among ideas or conscious representations of actual things and events.

Learning a maze, in fact, may engage all of one's mental processes. When a man or animal learns he works pretty much as a whole. The mental processes are rather artificial abstractions of parts of the total activity. Sometimes muscular activity and retention of the reactions acquired, as in the maze, are prominent; sometimes the conscious activities and retention of them, as in memorizing poetry or solving a problem in mental arithmetic, are relatively conspicuous; sometimes emotional acquisitions or control, as in learning to drive an airplane, are important. But in all of these the mechanics of learning are essentially the same,—many reactions, the elimination of those which annoy and the selection and strengthening of those which satisfy.

A Comparison of Memorizing and Maze Learning.—Let us examine a case of learning in which overt bodily movements are but slightly involved; one which is mainly observation and recall, but otherwise similar to

the maze experiment. Memorizing a series of "nonsense" words is a case in point. The subject is given a series of twenty words like the following:

> *nup, tib, nult, remp, zuc, ralt, marb, selz, kib, curg, toq, sor, dit, quos, viz, pelm, rulb, onk, qat, arz*

Such a list is by no means learned through sheer impression, absorption, or repetition. While the learner may not always realize it, the process comprises false starts and stops, errors, confusions, the addition of connections, elimination of connections—all of the features of learning a maze.

A typical attack by an efficient learner would be somewhat like this: First, a reading of the series for purposes of general orientation; next, perhaps careful observation of the first and second syllables and possibly the last two—nearly always these are learned first. Then the whole series may be broken up into units or "feet." The first foot may contain *nup, tib, nult* and be read with a rhythm such as ¯′⌣⌣ followed by similar groupings. The first syllable in each of these groups may be observed with special care. The learner may notice and try to remember that the last word of the first group, *nult*, has four letters, and that it is followed by another, *remp*, with four letters. However, he may discard this when he finds that *tib-nult* may be combined into a word that sounds a little like a town he once visited, and this in turn may be discarded when he observes that *nult* almost rhymes with *ralt*, which occupies a similar metric position. A word like *quos* is thought of as "such a mouth full"; whereas *viz* is "buzzy" and *dit* is short and snappy. *Selz* is remembered because it is short for "seltzer." Learners usually keep an active lookout for meaningful reactions and this is trial and error in its clearest form.

Suppose, for example, that you see how many meaningful associations you can make with *gip?* Note how you try, one after another, a great many ideas—some satisfactory, others unsatisfactory.

On the whole, memorizing a series of words, far from being a mere passive, mechanical process of repeating one syllable after another, is highly active—or reactive—and presents all of the features of other trial-and-error learning. The good learner is actively observing and searching for clues. He tries reacting by possible meanings, possible sounds, possible combinations with other words, possible similarities or contrasts. Many of these are tried out only to be discarded; others are selected; and before the list is learned the path is strewn with discarded trials. What is finally learned may be called roughly a series of reactions, just as the way through the maze was a series of reactions.

In memorizing, just as in learning a maze, one attains the first successful trip through the series after many trials, and even with that achievement much remains to be learned by further practice. There are recurrences of difficulties and errors—the curve of learning is zigzag, like that of the rat's in the maze.

Is memorizing a series of non-sense syllables exclusively a mental function? By no means. New types of eye movements might have been acquired and new articulatory reactions—those required to say *ralt,* for example. Even if one memorized silently, some of the speech organs were in action. Emotional learning was also involved, as it is in mastering any new function. One must acquire control of anger, mirth, chagrin, excitement, and perhaps other emotions which are very prone to arise in the early stages of adjusting to a new situation. When the learner looks at "*selz*" and in thinking

about it is reminded of "selzer," or when he discovers during thought that *tib-nult* is something like the name of a town once known, the process is similar to reasoning. So in memorizing, as in learning a maze, all of one's mental processes and other types of reactions may be employed.

The Limits of Improvement.—Learning the way through a maze or memorizing a series of non-sense syllables are relatively short processes—at least for human subjects—although it would be possible to make them so long and difficult that weeks of effort would be required for mastery. When the solution of such a task has been achieved, moreover, but few reactions, and these neither strictly new nor difficult, are required to repeat it. We simply walk through the maze or say words, finally; both are easy acts. It is the order of doing them that is new. When once this has been accomplished the remainder of the work is relatively simple and soon a performance limit is reached.

The Course of Improvement in Learning Complex Functions

Such complex functions as reading, writing, drawing, singing, playing the piano, typewriting, playing tennis, swimming, manipulating geometrical or algebraic data, diagnosing diseases, writing poetry or prose, running a bank, etc., require years of learning before a physiological limit is reached. In these cases the acquired reactions are very complex, relatively new, and ever changing, if one keeps on actually learning.

In Typewriting.—The experimental studies of type-writing afford about the best illustrations of the learning of such complex functions. If the subject learns by the

touch method, he starts to work as follows: Looking at his copy, he finds the first word "what" and thinks of "w." He now looks at a picture of the keyboard, locates "w," and then, finding a corresponding position on the actual keyboard (the letters of which are covered), he makes a stroke. The same procedure for "h" and "a" and "t." After a time, the task of looking at the picture of the keyboard is eliminated, first for a few and gradually for more letters. The process then is: see the word, think of the first letter, "w," think of its position on the mental picture or representation of the keyboard, locate its position among the keys, and strike. The keyboard has been reacted to consciously (by observation) until it may be represented mentally; i.e., it has been memorized. Of course this is a gradual process so that prior to complete mastery there is an overlapping; some letters may be recalled, while others must be looked up. Needless to say, writing at this stage is very slow and errors are frequent. Shortly the learner finds that the mental image of the position of the keys is unnecessary for certain letters; they may be thought of as on the board. Later, it becomes unnecessary to *think* of the position of certain letters at all. Merely seeing the letter to be written acts as a stimulus to carry the hand and finger to the right spot. The elimination of the several mental steps results in a great saving of time, energy, and usually, of errors. While there has been great progress, however, in respect to the elimination of many useless acts and the perfecting of the finger work in striking the keys, the learner is still in the "letter stage," making a particular complex reaction to each letter.

Further eliminations and selections, almost too subtle to be observed by the experimenter or to be appreciated by the learner, result in a combined reaction to two

letters. For example, when "what" is observed, the thought of the "wh" sets off two strokes as if they were a unit; the same for the "at" and for other similar units that are frequently encountered. While this unification is spreading to less familiar combinations, longer units such as "are," "the," "ter"; and soon "they," "ough," and later whole words or even phrases are written as unified acts. The transitions to broader units are made at different stages for different words; the easier or more frequently used first, the more difficult or infrequent later.

Meanwhile speed and accuracy have been steadily but irregularly increasing. Numberless futile reactions have been discarded. At first the learner may grit his teeth, press the table with his knees—literally write all over. These reactions are gradually eliminated as are more subtle irrelevant errors which result in hitting too hard or too easy, in missing the keys, or timing badly so that the keys clutter frequently. Periods of emotional upset, anger, chagrin, despair, disgust, great elation, and the like are very common at first, but are brought under control. In learning to typewrite, one must learn to adjust his emotional, as well as his motor, mechanisms to the situation. The elimination of conscious reactions, actual thoughts or images of positions—particular letters, particular movements—goes on similarly. In the expert stage there are, then, relatively few irrelevant reactions.

Characteristics of the Curve of Learning

From these descriptions of representative types of learning we may advance to a consideration of characteristics common to all, taking up first various features of the *curve of learning,* which gives a graphic picture of

the amount, rate, and limit of improvement brought about by practice.

Most of the functions learned in school or everyday life are very complex, including many particular S-R connections. During the progress of learning, changes in the combination of connections are constantly going on. The performance near the limit of improvement is not the performance at the beginning done more rapidly; it is a different performance. Curves of learning, consequently, portray the progress of improvement in a changing complex of connections. They do not picture the influence of exercise and effect upon single, or even upon a constant, group of S-R connections.

The actual curves of learning, which are available in large numbers, are of various shapes, which are determined in part by the nature of the function itself and in part by the ability, methods of work, and previous training of the individual learner and the circumstances under which he works. There is no single or typical curve of improvement, but many different varieties of which samples are given in Figures 25 to 30 inclusive.

Study of the various curves will show that a rapid initial rise is a frequent but by no means universal characteristic. The actual increase in the output rises rapidly in the earlier stages and usually more slowly at the final stages of an extended experiment on the acquisition of skill. This is not necessarily an indication that one is learning better in the early stages; usually it means only that what is learned has greater effect upon the score. When one begins to typewrite, for example, searching out each individual letter makes the number of words written per minute very few. But to memorize the positions of a dozen of the most commonly used letters, which is not a very difficult task, increases the

output greatly. When one has reached a speed of thirty words per minute most of the easy tricks have been mastered, and to secure an equal increase in the score demands the learning of a great many more difficult acts. If, on the other hand, we consider the number of new

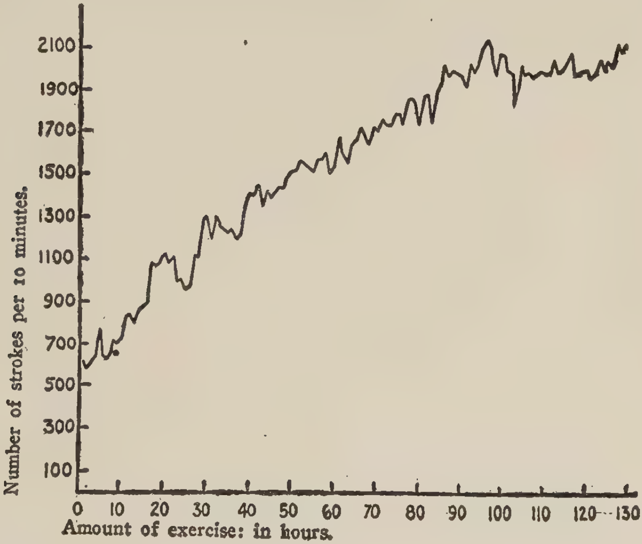


FIGURE 25. Improvement in typewriting by the "touch" method. Improvement is fairly uniform until the hundredth hour, where the curve flattens out. This is probably a "plateau" rather than the physiological limit. The highest speed attained is about 30 words a minute—not a high rate. (From Thorndike, *Educational Psychology,* Vol. II, p. 139, after Book.)

Latin words one can learn in a given unit of time, we shall probably find that it increases as practice goes on. This is due, mainly, to the fact that after one has mastered a number of roots, prefixes, rules, etc., it is an easy matter to pick up a dozen new words; the "new" words being, as a matter of fact, not wholly new but frequently composed of one or more parts already more or less familiar. This is generally the case in acquiring

information; the more history, psychology, or mathematics one already knows, the easier it is to learn a new lesson.

The Physiological Limit.—In the case of such skills as typing, writing, etc., an absolute limit of improvement is theoretically possible but practically almost never achieved. The *physiological limit* is that degree of

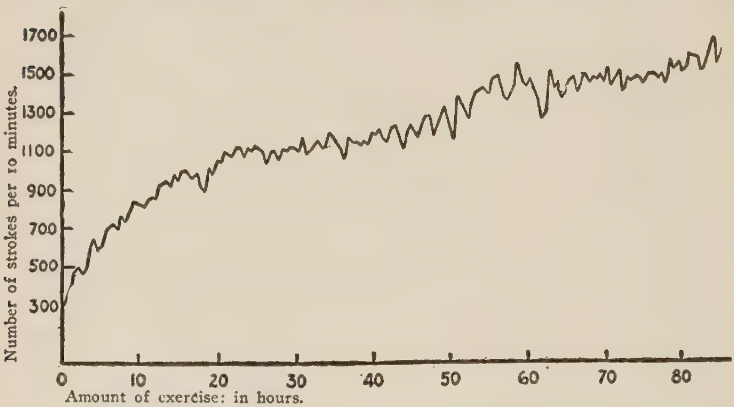


FIGURE 26. Improvement in typewriting by the "touch" method. Between hours 25 and 45, little improvement is made. This period might be called a plateau. (From Thorndike, *Educational Psychology*, Vol. II, p. 138, after Book.)

ability which a particular person cannot surpass because of absolute limits in the speed or complexity of motor or mental response. In running a hundred yards, jumping, tapping with a pencil, or other functions which depend upon sheer speed and force of muscular contraction with relatively little opportunity for developing new technique, the limit may be reached. But in complex performances such as typing, drawing, playing the piano, carpentry, or surgery it is very seldom reached. In acquiring information in any field—law, medicine, history—there is no physiological limit; there is always

more to learn and the possibility of learning it, although there is a limit to the speed with which the items may be acquired. But in most functions which have been steadily practised for years, such as writing, reading, shaving, opening envelopes, tying neckties, sorting cards, memorizing or studying, we are performing with a speed and efficiency far below our maximum possibilities. Under special incentives such as keen competition, typesetters,

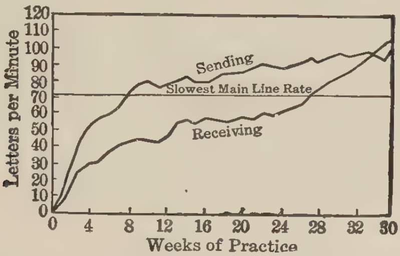


FIGURE 27. Improvement in telegraphy. The upper curve shows the results for transmitting messages; the lower the rate of receiving. Note just above the word "receiving" the plateau which extends over a period of nearly ten weeks, followed by a rapid rise. The line marked "slowest main line rate" indicates the slowest speed at which commercial messages are sent. (From Starch, *Educational Psychology,* p. 142, after Bryan and Harter.)

telegraph operators, and typists in industry, as well as readers, writers, or spellers in school, frequently rise abruptly from a dead level which has held them for years.

When any habit becomes fixed, it is invariably annoying to disturb it. The prime condition of improvement is that the performance at the time be broken up and reorganized in better form, i.e., on a higher level. Most of us eased off in our learning of reading, writing, and many other school functions as soon as we safely could—perhaps in the fifth or sixth grade—and entrenched ourselves in a low level performance, from which we have never emerged. Few people know how rapidly they read

or write, how efficiently they memorize or solve arithmetic problems; few know when their improvement came to an end, or whether they have made any improvement in the last year or ten years. If you should now suddenly undertake to increase your speed of reading it would be found disturbing and perhaps unpleasant for a time, the

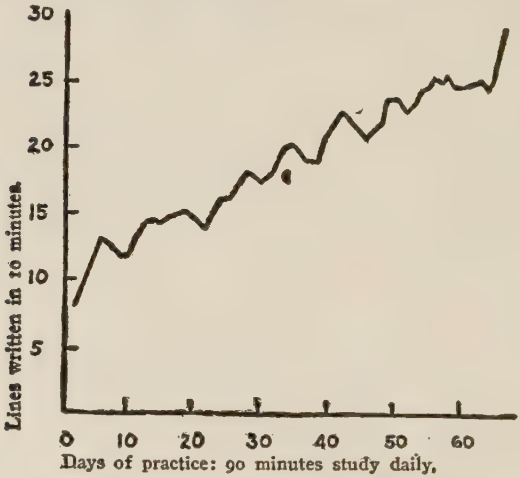


FIGURE 28. Improvement in copying a text in short-hand. The curve of learning is of fairly uniform steepness and shows no plateau. (From Thorndike, *Educational Psychology,* Vol. II, p. 141. After Swift.)

inevitable result of breaking up an old organization of habits to supplant them by new. But this is the only way in which more effective habits—perfectly comfortable once habituated—are attained.

Even in learning under experimental conditions, in which the incentives to improve are great, especially when each day's work is recorded, the progress measured, rewards offered, and competition provided as incentives, the tendency to ease up is quite common. Sometimes this shows itself in a level or "*plateau*" in the

curve, although some levels, even declines, are otherwise occasioned. Figure 27 illustrates plateaus out of which the curve of learning emerges to reach higher levels. Often under ordinary conditions of life or school, where actual improvement is less emphasized, cherished and rewarded, the plateau becomes a permanent level.

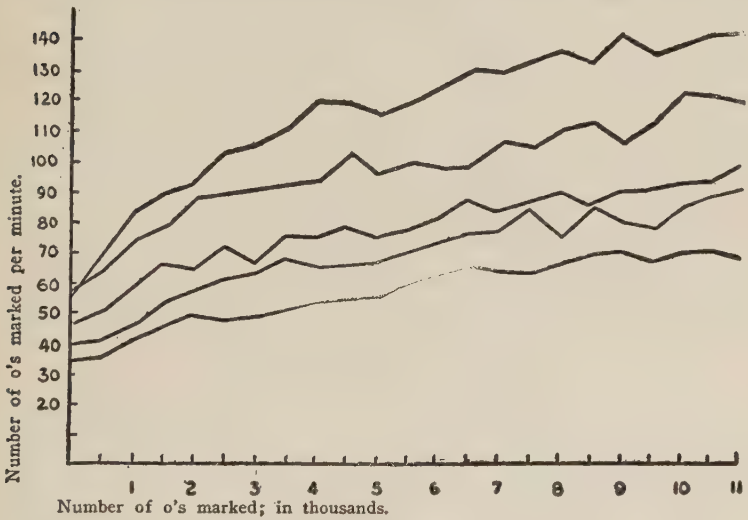


FIGURE 29. Improvement in cancelling *O's* from rows of digits by five subjects. Note that the shapes of the curves differ among individuals and that the largest improvements are made by those who show the greatest ability at the beginning. (From Thorndike, *Educational Psychology,* Vol. II, p. 124. After Wells.)

Plateaus in the Learning Curve.—Plateaus may, however, occur despite an interest in improvement and an effort to secure it. Sometimes they are due to unintentionally but unhappily hitting upon a bad habit or method which interferes with further progress until it is eliminated. In writing, a pupil may develop an unfavorable sitting position or too firm a grip of the pencil; in reading, a habit of pausing too frequently in

a line, or of giving too much attention to the minute details of words; habits which may inhibit progress until they are accidentally or by means of the teacher's instructions corrected. Plateaus may be caused by eye trouble, fatigue, and other physiological conditions, despite intentions to improve. Sometimes levels in the curve, persisting for days or even months and often dis-

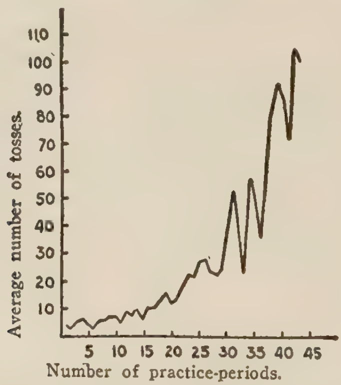


FIGURE 30. Improvement in tossing and catching balls. The improvement is slow at the start but becomes more rapid as the subject becomes more proficient. Compare with Figures 25 to 29. (From Thorndike, *Educational Psychology,* Vol. II, p. 120. After Swift.)

couraging to the learner, are encountered when actual progress is being made. In reading, the introduction of visual analysis of words may temporarily disturb the pupil's facility. When his performance is measured by the speed and accuracy of reading, he may appear to have lost some ability; but the cause of this apparent loss may be simply that the learner is passing through a period of transition to a higher level during which no immediate improvement is secured. Progress may be real but concealed, and the learner may emerge with greater ability to recognize new and long words. In typewriting such plateaus sometimes appear during the transition from

letter to word units. The shift from one stage to another is seldom abrupt; a good deal of overlapping is the rule, and while the one is shading into the other, errors and periods of confusion are frequent. The danger is that these will so annoy the learner that he will drop back to the lower but more familiar level.

Short Time Fluctuations in the Curve of Learning.— The plateau, which is a long time level or depression in the curve of learning, lasting for weeks or months, is not a universal characteristic of any function or any person; but short time, day-to-day ups and downs are practically universal. (See Figures 25-30.) These fluctuations are due to temporary habits, good or bad, differing bodily conditions, interests, distractions, incentives, or other temporary influences. Individuals will have their good and bad days, often for minor reasons that are difficult to discover.

The Influence of Disuse

Disuse is, of course, a passive state in which the mechanisms, trained during practice, are left inactive. The effects of practice gradually die out at a rate which depends upon the native retentiveness of the particular neurones for the particular individual concerned. There is no way in which one's neurones may be trained to greater retentiveness, so far as we now know. But without actual change in the retentiveness of the neural structure, better recall may be insured by utilizing the most effective methods of practice and the most effective methods of organization and presentation, which will be discussed in the next chapter.

No satisfactory information has as yet been secured concerning the precise rate at which particular con-

nections strengthened by exercise weaken through disuse, or to what limits the effects of disuse may go. The whole matter of the change in a particular bond occasioned by disuse must be treated hypothetically by deduction from the rather crude experiments upon complexes of connections, constituting functions such as memorizing words, learning telegraphy, and the like.

In the previous chapter, we described a case of a child who learned to react to the spoken word "leaf" by thinking of the object when the word and object were presented together repeatedly. To begin with, the connection between the word "leaf" and the conscious reaction or idea of leaf was very weak. In Figure 31 this is represented as above zero but below the "limen" of recall; that is, the connection is not strong enough actually to produce the response. One simultaneous reaction to the word and the object strengthens the connections somewhat, but not sufficiently to provide the response. Further repetitions gradually increase the strength of the connections until, perhaps, on the tenth repetition it barely exceeds the limen of reaction; that is, when we say "leaf" the child is barely able to recall the idea of the object. Each additional repetition further increases the strength until, perhaps, after thousands of repetitions, it reaches a limit—the physiological limit—which represents the strongest and most permanent connection possible. There are, then, various degrees of strength in a connection, from zero up to the threshold (or limen) of reaction and from that point on to a theoretical limit. One may learn a poem, for example, to a point where he can barely recall it, or overlearn it to various degrees. The more thoroughly it is overlearned, the more promptly, surely, and easily it can be recalled. If the reactions are now given no exercise, dis-

use gradually results in a weakening of the strength of the connections, which would result in a lessening of the promptness, certainty, and ease of recall and, finally, in inability to recall. But even when the connection becomes so weak as to lie below the limen, there are still differences in degrees of strength, or if you please, differ-

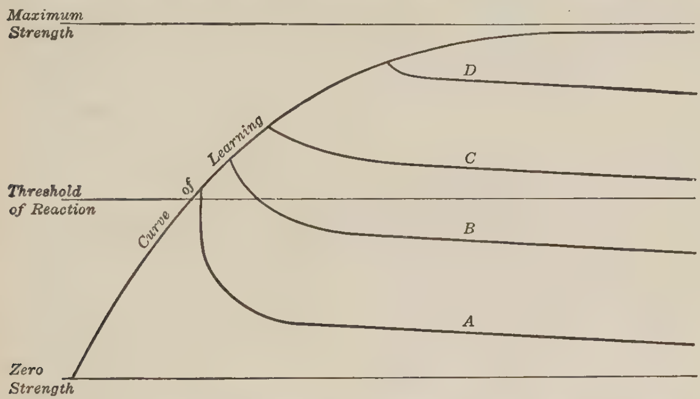


FIGURE 31. Probable influence of disuse in the case of functions overlearned in various degrees. *A* shows the loss or forgetting which occurs when the function is barely learned. The initial loss is rapid and great followed by a much slower rate of deterioriation. *B, C* and *D* show probable losses in functions which are overlearned slightly, considerably and greatly, respectively. In all cases, after the rapid initial loss, the strength of the connections steadily but slowly decreases.

ences in degrees of weakness between the limen and the zero point.

Overlearning and Disuse.—From the experimental studies, which are unfortunately very few, it appears that the rate at which connections lose strength through disuse depends mainly on how strong they were at the beginning of the period—in other words, on how much they were overlearned. Reactions greatly overlearned, such as our names, the A B C's, and many familiar words, or motor acts as holding a pencil, or humming "Home Sweet Home," will probably function after thirty, forty,

or more years of disuse, although they will have lost more or less of the original promptness and ease of action. Names of old friends, the appearance of the scene of a summer's vacation, a poem or song greatly overlearned, the act of catching a baseball, and other acts representing connections less thoroughly established will remain above the threshold of reaction for many years, and thus, by various degrees, we may come down to responses that were originally exercised sufficiently to place them barely above the threshold of reaction.

Curves of Forgetting.—It is upon functions barely learned that most of the experimental studies of the effects of disuse are based. Ebbinghaus, a pioneer investigator in this field, examined the permanence of his own learning of non-sense syllables after they had been barely learned—that is, learned until he had made just one correct recitation. Practice was given up, and after a period of disuse he relearned the same series. The loss in the strength of the connections—or, as it is more accurately expressed in this case, "the amount of forgetting"—is measured by the relative amount or percentage of time taken to relearn the material to the point of one recall. The loss of ability, as thus measured, is very rapid at first and then tapers off gradually. Strong has obtained about the same results, using different materials and a different method of measuring forgetting. Another investigator, Radossawljewitsch, found that when nonsense syllables were learned more thoroughly—namely, until they could be recalled twice in succession—the effects of disuse were not so great. The first investigator found that after twenty-four hours of disuse, two-thirds of the original time was required to relearn, whereas the last investigator found that when material was overlearned slightly (two correct recitations instead of one)

only one-third of the original learning time was required to relearn after twenty-four hours.

In Figure 31, the probable curves of disuse which may follow various stages of overlearning are represented. These relations, however, are merely estimates based upon the few facts now available. They are intended to present roughly the general facts that the rate of loss through disuse depends upon the degree of learning and that loss goes on both above and below the threshold of response.

Information is seldom overlearned to the extent that skill is. Writing, reading, speaking, typewriting, and swimming are complexes of large numbers of connections, some of which must be tremendously overlearned before even moderate proficiency in the function as a whole is possible. Many of the constituent connections, moreover, are really not idle during disuse, but are being exercised in other skills and thus kept strong. With complete disuse, the connections involved in motor functions do die out and, when originally overlearned to the same degree as the bonds involved in acquiring information, the rate of deterioration is probably about the same, although it is not impossible that the latter are somewhat less stable.

Practical Problems.—The practical problem for the teacher is to determine to what degree pupils should overlearn names and dates, multiplication tables, the spelling of a word, rules of grammar, courtesy, skill in writing, and other school functions. Should a particular ability be so learned as to be in working order for one day, one week, one year, or thirty years? Having decided on how thoroughly to overlearn, what is the best method of doing it? Should the learning be done wholly in one continuous period, in several periods dur-

ing the same day, or a few periods scattered over a week? Should the periods be ten minutes, thirty minutes, or an hour long? Should the lesson be learned in piecemeal or as a whole, at a high rate of repetition or slowly, by vigorous articulation or silently? These problems fall under a general discussion of economical learning to which the next chapter will be devoted.

QUESTIONS AND EXERCISES

1. In what respects is the learning of animals like that of man? In what respects is it different?

2. An experiment upon improvement in reading. For practice, attempt to speed up in all of your daily reading for 30 days. Try to bring about an increase in speed by pushing yourself beyond your ordinary rate. Give yourself a test, at about the same time each day, by getting some one to time you while you read for 10 minutes as rapidly as you can comprehend. For test material use a book of moderate and uniform difficulty. Record the number of lines read on each 10 minute test. Plot a "curve of learning."

3. Compare your progress with that of others. At the end of 30 days, see if you think you have reached your limit. How can you be sure whether you are on a plateau or at your physiological limit? Test your judgment by continuing the experiment. Was the general curve uniform or irregular? Can you account for the small variations from day to day?

4. Just what is meant by the physiological limit? In what functions have you reached your physiological limit? See if you can increase your speed of tapping or of saying the ABC's

5. Name functions in which a slight improvement can be attained only at a great cost of time and effort. Name some where the experiment is worth the cost; some in which it is not.

6. Give samples of functions in which a little improvement may be of enormous practical importance.

7. How may we determine the optimum development of school functions—reading, spelling, writing, typewriting, speed, and accuracy of multiplication? Cite opinions or experimental evidence concerning the degree of efficiency demanded by various vocations.

8. Can you give any illustrations from your own experience in which improvement has been blocked by the formation of inappropriate habits, loss of interest, staleness, or fatigue?

9. What is meant by "overlearning"? What is overlearned when one can typewrite 60 words a minute?

10. Cite a dozen functions which the high school graduate has overlearned. In what cases has there been too much, in what too little overlearning?

11. Suggest an effective way of relearning poetry or names in order to give special practice to those bonds which generally need relearning?

12. What does a pupil in school know about his curve of learning in various functions? What should he know? How might such curves be secured?

13. Criticise this statement: "We learn to swim in winter, and learn to skate in summer." Account for any appearance of improvement as a result of a period of no exercise.

14. Why is it that certain experiences of childhood are apparently very well remembered?

15. In what functions does it appear that loss is very great from disuse? In what ones does it appear to be less great?

16. James states that "Nothing we ever do is in strict scientific literalness wiped out." Just what is meant by this? Certainly, experiences are "forgotten," that is, cannot be recalled consciously. What has become of them and how may they function? What evidence can you cite to show that some trace of past experience may function years after it is forgotten in the sense that it cannot be consciously recalled?

17. Is there a single typical curve of forgetting for all functions?

18. If one plays tennis only 2 months per year, but plays baseball 3 months and handball 7 months, would you expect the skill in tennis to deteriorate during the 10 months as much as if baseball and handball were not played at all? Explain.

19. List and define all the new terms found in this chapter.

REFERENCES

Comprehensive brief accounts of the characteristics of improvement from practice will be found in the following:

F. N. Freeman, *How Children Learn,* 1917, chapters 8 and 9; Daniel Starch, *Educational Psychology,* 1919, chapter 11, and E. K. Strong, *Introductory Psychology for Teachers,* 1922, pages 29-98.

More complete accounts will be found in the following:

E. L. Thorndike, *Educational Psychology,* vol. II, *The Psychology of Learning,* 1913, chapters 6-10 inclusive; and W. H. Pyle, *The Psychology of Learning,* 1921, chapters 2 and 7.

CHAPTER XII

PRINCIPLES OF ECONOMY IN LEARNING

When a rat is placed in a maze or when a child is allowed to learn to read by the "natural method," a picture of unrestricted trial-and-error learning is secured in which native aptitude, previous experience, and, to a considerable extent, purely chance influences will determine the kind of reactions that will be acquired, and the speed of acquisition. It is the function of the teacher of children or animals to determine what should be learned and how well it should be learned, and to abridge the process by such devices as are effective. The human subject should be taught not only what connections to form but how to form them.

The principles of economy in learning to be considered in this chapter fall roughly into three groups, although the divisions are not sharp. They are as follows:

1. Principles derived from the general laws of learning
2. Principles based upon facts known about the native capacities of the receiving, connecting and reacting systems
3. Principles based upon experimental studies of the organization and control of practice

Principles Derived from the General Laws of Learning

If the teacher assigns a spelling list of ten words and requests a recitation the next day, there may be as many

different methods of learning as there are pupils. Some of the methods may be good, but some may be very bad indeed. There is no greater educational fallacy than the notion that the methods of learning which a pupil discovers for himself—the so-called "natural" methods—are the best for him. The procedure which the pupil is most likely to adopt is the first one stumbled upon which enables him to get the lesson. Children can often learn the ten words despite the most laborious and wasteful methods. How many children left to themselves, for example, would have adopted the "touch method" of typewriting which is demonstrably superior to the innumerable variations of "hunt and hit" that unguided learners develop? How many children will learn to write, swim, or to play the piano, by an approved method without being taught? Very few, certainly. The same thing is true of learning to read, multiply, add, or learn vocabularies, names, and dates; the only difference is that in the latter functions it is very difficult to detect precisely even very serious defects or deficiencies.

In learning of the factual type, part of the trouble is due to the notion, often accepted in practice if not in thought, that a fact is a fact, and that it will function without regard to *the way in which* it was acquired. It is often assumed that if multiplication tables, vocabularies, or names and dates in history are thoroughly learned, it matters little how they are learned. This is to completely disregard the fact that what we learn in these cases is not subject matter but, as elsewhere, particular reactions. We have added to our equipment certain responses which can function only in certain ways, ways determined by the manner of learning.

Learning as Reacting.—The first principle of learning, already mentioned but in need of further elaboration

and illustration, then, is this: what we learn are the reactions that we make. An investigator once asked a large number of students whether the four on their watches was a IV or a IIII. Of 200 students whose watches carried a IIII, 179 declared it was IV. In spite of the fact that they had looked at their watch faces hundreds of times, very few had made the specific kind of reaction to the IIII which would enable them to recall it as such. Similarly 192 reported that six o'clock was indicated by VI, when as a matter of fact there was no numeral at all at that hour. In another investigation, the experimenter told classes of college students that he wanted to test their ability to spell a list of words. When the six words had been written and the papers collected, the students were asked to write again the six words in the order given. Of 236 students, only five per cent recalled all of the words in the proper order; twenty-five per cent could recall the words but not the correct order, and five per cent could remember only half of the words and then were uncertain of the order. The explanation is that, having heard a word, to write its spelling is one kind of reaction, while to memorize a list of words in their order demands a very different kind of reaction.

In another case, the facts are illustrated more clearly. A student in the course of some statistical work found it necessary to use the squares of numbers from 13 to 30. Using a table which gave these numbers and their squares, the reaction—think of the number, find it on the page, look at the square, write it down—was made several hundreds of times for each number in the range; but afterwards upon test it was found that only five squares (those of 13, 15, 20, 25, and 30) could be instantly recalled. If a different reaction—roughly, think of the number, then think of its square—had been

exercised specifically all the squares could have been memorized in a short time. In the first case, the ability to find numbers and their squares had doubtless improved greatly by use; but the reactions required for recall had not been specifically exercised and consequently were not acquired. Consider the learning of a vocabulary which is given in the book as follows:

1. *Der Mann*—the man
2. *Der Knabe*—the boy
3. *Der Hund*—the dog
4. *Das Haus*—the house

Suppose that the child learns the vocabulary by reading the pairs, one after another, in the order given. What connections are formed? Bonds between the pairs and their position in the series are made, and are especially strong in the case of the beginning and end of the list. Thus, *Der Mann* is connected with its firstness, *Der Knabe* with secondness, etc. Bonds between the first pair and the second pair, the second and third, etc.—that is, serial connections, like those acquired in learning a series of non-sense syllables—are also formed. Strong connections between the end term of one pair and the beginning of the next ("man"—*Der Knabe* and "boy"—*Der Hund*) and between the various end terms ("man—boy—dog"—etc.) are also established. Learned in a list a great number of such connections are made, and it is upon these that the reaction may largely depend. Now, suppose you ask the boy to give the equivalent of "house"; or suppose *Der Hund* is written alone on the board. He may fail to make the correct responses in both cases although he could say the whole list as he learned it. It is something like asking an adult to give immediately the letter which precedes "q" or "o"; unless

he has previously practised just such reactions, he must get the answer in some round-about way.

One must learn precisely the reaction that will be needed for practical purposes. Ordinarily, we study the German-English vocabulary so that later, on seeing the German word in isolation or in various contexts we can react with the thought of its English equivalent. A good method of learning, then, would be to take small cards and to write on one side the German word, on the other the English. Shuffle several such cards in order to avoid forming the serial, position, and other irrelevant bonds. Look at the German word and try to recall the English equivalent. This demands the reaction that one will later be called upon to make.

Reading vs. Recitation.—In one investigation two general methods of reacting were tested in the course of memorizing materials. One method consisted of reading and rereading a list of 16 non-sense syllables (or a group of five short biographies totalling about 170 words) without looking up from the paper. Another method consisted in beginning, early or late, to recite—that is, to attempt to recall when not looking at the material—prompting one's self speedily by glancing at the paper when unable to proceed. The latter kind of reaction is just the kind that will be demanded later. The question is, does exercising as soon as possible the reaction that will eventually be demanded result in more economical learning and retention than the method of reading and rereading?

The "recitation" method turned out to be quite superior, as shown by the accompanying table.

A study of the table will disclose several facts: (1) The greater the amount of time devoted to recitation, the greater the percentage of the lesson recalled. Of

Recitation versus Rereading (from Gates)

MATERIAL STUDIED: 16 NON-SENSE SYLLABLES, 5 BIOGRAPHIES = TOTAL OF 170 WORDS

	PER CENT REMEMBERED		PER CENT REMEMBERED	
	IMMEDIATELY	AFTER 4 HOURS	IMMEDIATELY	AFTER 4 HOURS
All time devoted to reading	35	15	35	16
1/5 of time devoted to recitation	50	26	37	19
2/5 of time devoted to recitation	54	28	41	25
3/5 of time devoted to recitation	57	37	42	26
4/5 of time devoted to recitation	74	48	42	26

course, some time must be spent at the start in reading the material. After a few readings the process becomes partly recitation; that is, one skims over the items that are familiar, seeing a bit here and there and filling in the gaps by recall. This is true of the ordinary reading of most adults. This explains (2) the fact that one does better, relatively, in learning sense material by reading and rereading than in learning non-sense words, which, to begin with, contain fewer meaningful associations which make recall during ordinary reading possible. (3) The recitation method results in the learning of a different group of bonds, the kind that makes for more permanent retention, as indicated by the fact that the greatest superiority is shown in the columns of the table which give the percentages remembered after four hours.

As pointed out previously, one may learn a thing in

several different ways. The best way is to learn it in exactly the form that will be used later. This is precisely what the student does when he learns by recitation. He forms and practices the reactions just as they must be exercised in recall at a later period. Another advantage of the recitation method is the fact that during learning one discovers just what parts are especially difficult or easy, and distributes his energy accordingly. He finds what kinds of associative aids work and what kinds do not. Finally, the learner is aware of his progress during active attempts at recitation. In the rereading method, some were uncertain as to whether they were mastering the lesson or not; the learning becoming very irksome on that account. During recitation the learner is stimulated and encouraged by the awareness of making progress; and clear evidence of success is a great motive in learning.

The first guiding principle, then, is to consider the situation which life will present and so arrange the circumstances of learning that the pupil will be practised in making those reactions which life will demand. Do not expect the proper response to appear as the result of incidental training.

It is not enough that the instructor realize what reactions are to be acquired; the learner must also know just what he is supposed to learn. Two general problems, then, merit consideration: (1) how may we best make clear the reactions that are to be acquired, and (2) how may we best determine the reactions which the learner is making?

The Choice and Use of Models.—In attempting to portray what is to be learned, teachers usually employ some kind of a model. For example, in teaching handwriting there are a number of possible models, among

which are the following: (1) a perfect copybook sample; (2) a splendid sample of actual writing; (3) actual handwriting, but less perfect; (4) actual writing but within the range of the child's possible achievement in a month (or more); (5) the sight of the actual writing movements by the teacher; or (6) moving pictures of the hand in motion. Which of these are useful? A great many elaborate investigations must be performed before the facts will be known with certainty. We must take our guidance from general principles until the crucial experiments are performed. The one general principle of which we feel rather sure is this: other things being equal, that model which makes the desired reactions most clear is best. It does not matter in the least whether the model is a living movement, a picture of a movement, a lifeless copy, or what. The one criterion is the faithfulness and clearness with which it displays the ends sought.

A perfect copybook model, because of its perfection, portrays the results of reactions that the learner will not soon—in fact, never—achieve. To see the teacher in the process of writing is of surprisingly little value. Inasmuch as he does not know what to look for, the learner frequently does not see anything that is helpful. Sleight-of-hand performances would never have been cultivated if this were not true. Of course, the teacher can demonstrate a few things about the finger positions in gripping the pencil, but the finer details cannot be perceived during the course of the actual movements. A well written sample is probably the best guide, when the pupil is assisted by certain explanations and demonstrations and a great deal of supervision.

Putting the Learner through the Reaction.—Another form of teaching which now and then attains popularity

is to put the individual mechanically through the reaction. Letters may be carved in a board through which the pupil pushes his pencil, or the teacher may grasp the child's hand and force the movements. There are two ways in which putting the learner through the reaction might be of utility: (1) by providing a clear idea of what is to be done and (2) by giving the mechanisms artificial exercise in the way they should function. At first thought, this should provide a simple way of eliminating the errors from what would otherwise be trial and error learning. No conclusive experimental tests of this device have been made on human subjects, but a number of them performed on animals show that they fail to profit by being put through a reaction which is for them about as new as writing is for a child. Even with his superior equipment for observation, the child does not realize very clearly what is happening when he is put through a complex act; usually he profits more by seeing someone else do the act. Furthermore, it is usually impossible to put him through more than the gross movements, and these at a much slower pace. The *feeling* of the movements—that is, the muscular and related sensations—are altogether too vague and confused to be valuable. Finally, the exercise is, after all, not the exercise of actually doing the act. You learn precisely what you practise; and in being put through, you learn not to write, but to be put through movements that are vaguely like writing movements. By tracing in a groove, one learns to trace in a groove; but actual writing is a different matter which must be acquired largely by itself. The novice who practises swimming while supported with an inflated tube, after all usually fails to learn to swim by this means alone while learning a number of things—such as balancing on the support—which are irrelevant.

Avoiding Irrelevant Connections.—Many handwriting systems afford good examples of superfluous learning. Those which begin with a series of exercises like the following are likely to be wasteful.

What is learned by making these pretty designs is to make such pretty designs; writing is another matter. Time spent on these exercises, of course, is not wholly wasted. Certain kinds of facility will transfer to actual

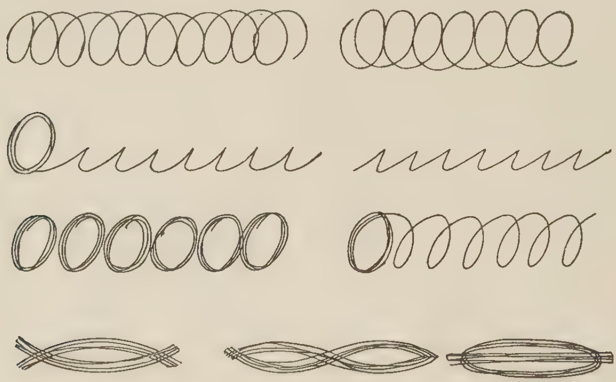


FIGURE 32. Samples of formal exercises sometimes used in teaching handwriting.

writing, but it will be only a partial transfer. What we want is practice that counts a full hundred per cent. One should, in fact, begin at once to write, although the character of the writing and the details of procedure should be the subject of careful instruction and guidance. Such exercises as were given above sometimes find their place in assisting in overcoming certain difficulties or in remedying defects, but they should not be used indiscriminately.

The theoretical basis of such exercises as the foregoing is the mistaken notion that if we learn to do singly all of the elemental acts involved in a complex function,

putting the single acts together will be relatively easy. The fact is, that the greatest difficulties are often encountered in putting the elements together, and that in a straightaway attack the elemental reactions are often sufficiently established without the preliminary work. Those that are not sufficiently developed may well be handled singly, but not until this becomes necessary.

The foregoing statements are true of very closely integrated functions, such as writing, reading, and drawing. In a large measure the analytical methods of teaching reading have been discarded. We do not now teach first the letters, then the phonetic elements, then the syllables and finally the words. We begin with words, and later introduce such phonetic or other analytical work as may be needed. In arithmetic, however, conditions are usually quite different, because we are dealing with a host of relatively specific abilities. The same rule applies there, however, in the sense that no irrelevant or useless bonds are to be formed.

The undue use of "crutches" in arithmetic is a case in point. Many teachers use temporary devices or "crutches" to assist pupils more rapidly over a difficulty, and by so doing provide more difficulties than they have escaped. Adding and subtracting by counting on the fingers, writing the number to be carried, writing the sign + or — or × to guide the computation of such problems as

$$\begin{array}{r} 568 \\ +\,321 \\ \hline \end{array} \qquad \begin{array}{r} 568 \\ -\,321 \\ \hline \end{array} \qquad \begin{array}{r} 568 \\ \times\,321 \\ \hline \end{array}$$

are common examples. The objection to such usages is not that they are childish, but that they represent the formation of habits that will sooner or later have to be broken. Moreover, their use is often positively detri-

mental in crucial cases. When speed is needed, counting on the fingers is too slow. If the + or — sign is omitted the pupil may be unable to proceed. Suppose the habit of writing the number to be carried is not broken before long division or multiplication is reached. We then will have computations appearing as shown below in which the eye is distracted by irrelevant figures which make frequent errors probable.

389	.47
276	———
———	685) $325.00
55	32
2334	2740
66	———
2723	5100
11	53
778	4795
———	———

Concerning all forms of crutches and special devices, the general recommendations are to consider carefully: (1) what new elements are introduced; (2) in what manner they will assist; (3) whether their utility is temporary or permanent; (4) how difficult it will be to break the habits formed; and (5) what other, if any, unfavorable adjustments may be introduced incidentally. The main principle of guidance should be: form no habits that will later have to be broken unless there is very good reason for so doing.

The Discovery of Errors.—The abridgment of trial-and-error learning is greatly facilitated by preventing and correcting errors. Errors sometimes may be prevented, as in the case of learning grammatical forms by presenting only the correct model. A list of equal numbers of correct and incorrect grammatical forms is then

undesirable since it results in the exercise of incorrect forms that might otherwise have never been encountered at all. The general principle is to give the erroneous reaction the least possible exercise. The usual situation is, however, that some of the pupils have acquired wrong expressions from various sources, and these must be eliminated as promptly as possible. On an earlier page was explained the fact that undesirable reactions are eliminated by (1) detecting them; (2) attaching annoyers to them; (3) providing a desirable substitute; and (4) exercising and attaching satisfiers to the substitute.

In the subtle elements of writing, speech, arithmetic. and other functions, the teacher should be constantly on the alert for errors that are likely to appear. She should detect them when possible before they become fixed, point them out to the learners, and attempt to introduce the correct reaction. When errors recur, they should be challenged and the proper response again suggested. When the error is once eliminated, it should not be mentioned again. Emphasis should then, in general, be placed on the correct reaction; but the incorrect response when made should not be ignored.

The learner himself should be alert to detect errors and to discover their cause. In arithmetic, for example, habits of verifying results should be established early. "These habits of testing an obtained result are of threefold value. They enable the pupil to find his own errors, and to maintain a standard of accuracy for himself. They give him a sense of the relations of the processes and the reasons why the right ways of adding, subtracting, multiplying and dividing are right, such as only the very bright pupils can get from verbal explanations. They put his acquisitions of a certain power, say multi-

plication, to a real and intelligible use, in checking the results of his practice of a new power, and so instill a respect for arithmetical power and skill in general."[1]

In writing, errors in position, in the grasp of the pencil, and in finger or forearm control are likely to creep in at any time, since these functions are in the process of development for several years. In such complex functions, the detection and elimination of errors is a vital feature of economical progress. In learning to read well orally, to recite, debate, etc., the recording of one's performance by a phonograph by which it may be reproduced and studied is a tremendous aid. Similarly photographic studies have proved most profitable in the analysis of movements in industrial operations for purposes of guiding the process of learning. It is quite possible that moving pictures of one's motor acts in drawing, shopwork, athletics, etc., would afford equally profitable study.

The Directing of Attention.—In connection with these suggestions concerning the value of directing attention to and discovering errors, an erroneous theory of the value of concentration on the sensations which arise from the activities of the muscles, tendons, and joints merits a word. This theory assumes that if one is attending to the sensations from the organs of response when a good reaction happens to be made, he may later reinstate the response by calling to mind the complex of sensations. As one writer puts it: "A movement idea is the revival, through central excitation, of the sensations, visual, tactile, kinesthetic originally produced by the performance of the movement itself. And when such an idea is attended to, when, in popular language, we think hard enough of how the movement would "feel"

[1] THORNDIKE, *The Psychology of Arithmetic.* 1922. Page 81 f.

and look if it were performed, then, so close is the connection between sensory and motor processes, the movement is instituted afresh."

Ask a golfer what ideas he tries to activate before making a stroke. No one will say that he tries to recall the hundreds of sensations from the body that he previously felt during the process of making a good stroke. He could not possibly do so if he tried. His ideas may be thoughts of cautions such as: "Now, don't get excited," or "Take your time," or "Keep your eye on the ball." As for the expert, the less he thinks about how he feels or how it felt to make a good stroke, the better. He simply makes the preparatory reactions, places feet, bends knee, and places the club proper to the general situation and goes through with the stroke with no thoughts of the movements whatsoever.

The whole notion that one profits by attending to the sensations from the members employed in a complex act is erroneous. What one should do is to direct one's attention to (1) features which enable one to secure the correct preliminary orientation; (2) features which enable one to detect errors or successes in the act; and to (3) the general outcome of the act. If one is trying to throw a baseball over the plate, he must first observe and thereby locate the plate. When the movement is under way it is wise to look at the plate, although at times—in practice—it pays to give attention to some part of the process which is troublesome. Thus, the pitcher may be stepping out too far; an error which he must detect and remedy. He should know both when his moves are incorrectly and when they are properly performed. As soon as he gets the act going right it is better to think about it no longer. The other feature which deserves attention is the outcome of the total act:

the pitcher should try to observe accurately just where the ball went, and try to account both for successes and errors.

The same principles hold for other forms of motor activities. In writing, one must first get the correct position and, second, keep on the lookout for good and bad movements by watching the product, trying at the same time to detect the causes of errors and successes. As one masters the act, the conscious reactions gradually drop out because they are unnecessary. Nowhere does the attempt to get an idea of how a movement feels contribute anything useful to the production of the movement.

Principles Based upon Facts Known about the Native Capacities of the Receiving, Connecting and Reacting Mechanisms

It has been urged at times that we may learn more readily through some sense organ than others, that we may learn more readily by one type of imagery than by others, that we learn more readily through certain forms of motor expression, and that we learn better at certain speeds. Each of these problems deserves some attention.

The Avenue of Presentation.—Are children or adults by original nature so constituted that they acquire most readily reactions aroused by means of visual, or auditory, or tactual, or some other sensory stimulation? So far as we know, the primary and higher neural connections of the brain aroused through one sense organ are just as modifiable and retentive as are the centers stimulated by others. Other things being equal, we learn quite as readily through one sense as another, with the exception, of course, of individuals whose receiving, connecting, or

central mechanisms are defective. Other conditions, consequently, determine which avenue of presentation is to be preferred. Very young children learn new words better, for example, when presented to the ear than when presented to the eye, for the reason that their early word experience is auditory and not visual. If they have attended school, by the average age of eight or thereabouts children learn better by means of reading. The reasons, however, are not physiological but mechanical: the child can regulate the speed of reacting to the words to suit his capacity; he can attempt recall when and where he pleases; he can stop and repeat the especially difficult items, and disregard those already mastered.

The relative values of moving pictures, graphs, diagrams, mechanical instruments, verbal explanations, and clay models are similarly determined by past experience and mechanical advantages. The main questions are: which method makes most clear the thing to be learned and which does it most interestingly and most economically of time, space, and money. Original nature is not so organized that we learn pictures better than words, or graphs better than models.

Types of Mental Imagery.—The question of the relative value of various avenues of presentation is usually linked with the problem of mental types. Some of the older books on psychology urged the teacher to discover the type of imagery used by each pupil and present material to harmonize with it. This advice was based on the assumption that children fall into definite image types, as the "eye-minded" type, the "ear-minded" type, the "motor-minded" type, etc.; and on the further assumption that when the imagery is predominantly visual, material should be presented through the eye, and

when predominantly auditory, through the ear, and so on.

Both assumptions are wrong. Nearly all children can and do employ all of the common types of imagery, which may vary from time to time, and from one kind of task to another. Furthermore, when one type is favored—for example auditory or motor imagery—impressions received through the eye may be at once converted into it. It is not at all necessary to employ vivid visual imagery in recalling or imagining scenes and events as in painting or in drawing, or to utilize none but auditory imagery in thinking of, playing or composing music. Of one hundred eminent musicians (including performers, teachers and composers) who answered the question "In what ways do you memorize?" sixty per cent reported that they used more than one type of imagery. Sometimes they used one at a time, sometimes several with visual, auditory, and motor reported about equally often; and more than one-third of the group were not aware of using any type of concrete imagery. They study the piece, as one says, "until it gets into the fingers; then it is recalled without consciously seeing or thinking notes."

Vivid imagery, as many studies have abundantly shown, is not essential to effective learning of school subjects. The reactions demanded in spelling, reading, drawing, or history may be acquired without any one variety of imagery. Pupils whose concrete imagery is very vivid are in general as likely to be dull as bright, and successful as unsuccessful, in particular subjects. Experienced mathematicians, scientists, and other mental workers have, as a rule, much weaker imagery than children. This apparently is due to a gradual discard, by trial and error, of vivid imagery and by the substitution

of verbal or other symbolic forms, or, possibly, the direct awareness of *meanings* with no imagery at all.

The image type of the pupils is a matter that teachers may well disregard, not only because it is very seldom of importance, but also because there are at present no reliable methods by which the imagery of children can be diagnosed.

What Form of Reaction is Most Readily Acquired?—Are children or adults so organized by original nature that reactions made by some mechanisms are more readily acquired and permanently retained than reactions made by others? One may practice the spelling of a word by articulating, writing, typewriting, tracing in the air with a full-arm movement, moving the eyes or any other member; or by reacting by visual, auditory, or other types of imagery. Which is the best way? So far as evidence now available goes, the neural connections concerned in one reaction appear to be as readily modifiable as those concerned in others; so the choice of the form of reaction should be determined by the now familiar principle: *Learn the act in the way it is to function in actual life.* For most of us, learning to spell by means of actual writing would, therefore, be preferred, although oral spelling might be learned quite as easily.

Speed versus Accuracy.—Speed and accuracy of reacting or of learning generally go together in the sense that those who develop one readily usually develop the other readily. But if we consider a particular individual, emphasis on one may or may not result in improvement of the other. The results vary with individuals and with functions.

In one series of experiments, it was found that in estimating lifted weights, in comparing the lengths of lines

or specimens of handwriting, increasing the speed at which judgments were made within limits produced but little or no decrease in accuracy. In comparing specimens of writing, trebling the speed actually produced a slight (6.3%) increase in accuracy. In thrusting a pencil at a point on a target at arm's length and in tracing an irregular line with a pencil, decreases in accuracy —slight for small increases in speed but considerable for great increases—were found.

In arithmetic and in writing, accuracy or quality is likely to suffer if speed is over-emphasized. When proper precautions are taken, however, the rate of performance can often be appreciably increased without sacrifice of quality or precision.

In certain school functions, notably in reading, great increase in speed may often be obtained with no loss—indeed, often with a gain—in accuracy. In the accompanying table are given the results of a special "drive" extending over 39 school days for the purpose of increasing the speed of silent reading.

THE GAIN IN SPEED AND COMPREHENSION RESULTING FROM 39 DAYS OF TRAINING DESIGNED TO INCREASE SPEED. (FROM O'BRIEN)

GRADE	NUMBER OF PUPILS	NO. WORDS READ PER MINUTE AT START OF TRAINING	NO. WORDS READ PER MINUTE AT END OF TRAINING	GAIN IN WORDS PER MINUTE	GAIN IN PERCENT	GAIN IN COMPREHENSION PERCENT
IV	236	155.7	236.4	80.7	41	5.4
V	154	190.7	277.8	87.1	46	3.5
VI	128	197.8	292.6	94.8	48	–3.0
VII	206	205.6	321.6	116.0	45	1.2
VIII	92	220.8	393.0	172.2	78	–0.9

The increase in speed is enormous, averaging approximately fifty per cent, while comprehension, on the whole, is influenced favorably.

Principles Based upon Experimental Studies of the Organization and Control of Practice

In this section such questions as the optimum length of a study period, the optimum interval between periods, the distribution of reviews, and related problems will be considered. With as many different subjects as there are, and with as many variations of the length of assignments, study periods, and intervals as are possible, it is apparent that an enormous number of investigations must be conducted before all of the facts are known. While the number of studies is large, crucial evidence is lacking in many instances; and in some subjects no investigations have been made. Guidance, however, had better rest upon the implication of such experimental results as are available than upon mere opinion. The statements in the following sections, however, are offered subject to revision in the light of results of future research rather than as final principles.

The Length of Practice Periods.—How long should one continuously study geography, spelling, or arithmetic or continuously practice writing, typewriting, or sewing? The results of a large number of investigations are not altogether in harmony, but they favor periods of thirty minutes or less as compared to longer periods.

In one investigation of learning in "substitution"—a rather difficult function in which the letters of words are translated into other symbols by the use of a code—a group of subjects practiced for sixteen days, using periods of the same length, and then were divided into four groups, one practicing 15 minutes a day, another 30, another 45, and another 60. The improvement in speed in the second practice period was then compared with the increase in the first period when all were practicing in

periods of equal length. This is shown in the accompanying table.

THE RELATIVE IMPROVEMENTS IN SPEED OF SUBSTITUTION WHEN THE SAME AMOUNT OF PRACTICE TIME IS DIVIDED INTO PERIODS OF DIFFERENT LENGTHS (FROM PYLE)

GROUP	LENGTH OF PERIOD	RELATIVE IMPROVEMENT
A	15 minutes	22.3 per cent
B	30 "	36.1 per cent
C	45 "	25.0 per cent
D	60 "	14.8 per cent

The thirty-minute practice period yields greater returns per unit of time than longer or shorter periods. The sixty-minute period is especially unproductive.

Other investigations of memorizing, archery, typewriting, and arithmetic have shown, in the main, that periods longer than thirty minutes are relatively unproductive, as are very short periods of ten minutes or less. The facts vary somewhat with the functions and with the age of the individuals, but, roughly, periods from twelve to thirty minutes are most desirable.

The Distribution of Practice.—If a learner has at his disposal seven hours a week for practice in typewriting, playing the piano, singing, etc., how may the time be most fruitfully distributed? Should he work continuously on one day for seven hours, or in half-hour periods —which, as we just found, are optimum—with intervals of a half hour, an hour, six hours or twenty-four? Experiments have not yielded entirely conclusive results, and but few functions have been tested at all; but there has been a rather consistent indication that by breaking up the available time into periods of thirty minutes, or somewhat less, with intervals varying from thirty minutes to twenty-four hours between, the best returns are secured. Thus it would probably be preferable to make use of the seven weekly hours by practicing twice a day

for thirty-minute periods; or, if but three and a half hours were available, half-hour daily periods would be advisable. That is, one should make the practice periods no longer than thirty minutes and distribute them at fairly uniform intervals, of not more than twenty-four hours. If only two hours per week are available, one should divide the time into daily lessons of seventeen minutes each. When this scheme of distribution reduces the length of the lesson to twelve minutes or less, it would probably be better to increase the intervals to forty-eight hours rather than make the practice period too brief.

The problem is slightly different when the task is to learn a speech, a short vocabulary, a particular musical selection, or a multiplication table. Should one learn such short lessons at one sitting, or at several sittings with intervals between? But little experimental work has been directed specifically to this problem. In one of the best studies, a series of items to be memorized were read from start to finish at a constant rate, and then repeated at fixed intervals until mastered. Typical results are shown in the accompanying table.

The time required when repetitions are made at intervals of twenty minutes or more is very small compared to the time required for nearly continuous study, at least in the case of memorizing to the point of bare recall.

The Distribution of Reviews.—When material has been learned sufficiently to be recalled, how should further practice be distributed when it is desired to have the facts permanently learned, as is often the case with certain facts in history, poetic gems, rules of grammar, combinations in arithmetic, and the spelling of words? Should the overlearning be carried out at once or should it be distributed over periods of weeks or months?

The evidence bearing on this problem is insufficient to

The Number of Repetitions Required to Learn a Series of Items Reread at Different Intervals (From Pieron)

Interval between repetitions	Subject I: Number of repetitions to learn	Subject II: Number of repetitions to learn	Subject III: Number of repetitions to learn
30 sec.	11	. .	14
1 min.	10	12	8
2 min.	8	11	7
5 min.	6	7	5
20 min.	5	. .	4
1 hour	5	. .	4
24 hours	5	6	4
48 hours	5	6	. .

justify a confident statement, but it indicates that one should overlearn somewhat at the beginning and leave the remainder of the overlearning to reviews at constantly increasing intervals. The first review, which should be relatively long, may be held after an interval of forty-eight hours; the next review, somewhat shorter, a week later; the next, shorter still, three weeks later; the next, two months later, followed by other reviews at intervals of six months or more.

In this connection, the distribution of practice and reviews provided by school texts of arithmetic, history, spelling, and other subjects provide interesting study. Figures 33, 34, and 35 show the distribution of practice on certain processes in arithmetic in the first two books of a three-book series of arithmetics. The diagrams which represent nearly four years of school work, from about the beginning of Grade 3 to the end of Grade 6, show no very consistent nor very good plans of distributing practice. Figure 36 shows a closer approximation to an ideal arrangement for reviews.

The Whole versus the Piecemeal Method.—If one were given a lesson of substantial size to memorize, he might master it part by part or read it through from beginning to end, thus gradually learning it as a whole. The fact that repetitions of an item at intervals is a more

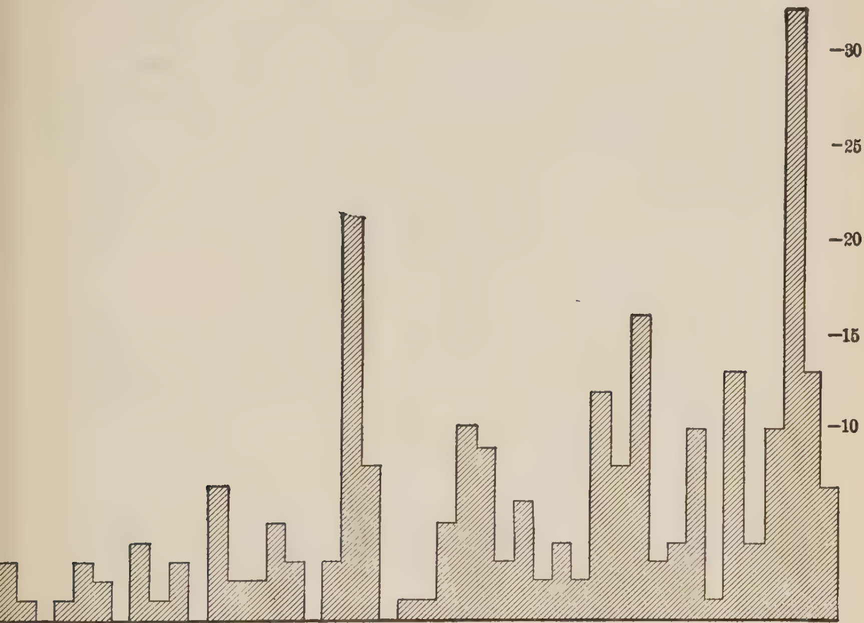


FIGURE 33. Diagram showing the distribution of practice on 5 × 5 over approximately a four-year period from the beginning of grade 3 to the end of grade 6. If the distribution were reversed it would be better. (From Thorndike, *Psychology of Arithmetic*, p. 165.)

effective method of learning than concentrated repetition gives the whole method some advantage, since learning a short stanza of poetry, for example, results in very brief intervals between the repetition of a given line, whereas reading through many stanzas results in longer intervals. In addition to this advantage, several others that are probably more important are inherent in the

whole method. The attack is usually more active for one thing; the short unit seems to result in a more superficial manner of study; certain useful types of reaction—

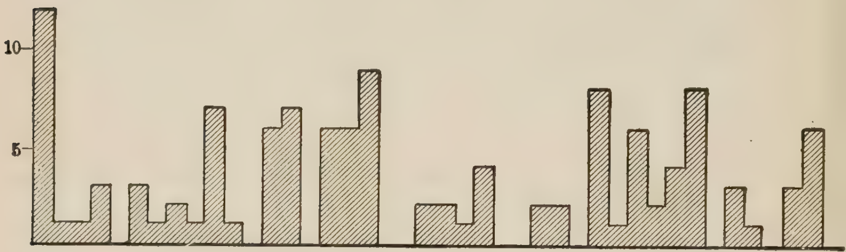


FIGURE 34. The distribution of practice on 7 × 7 over a four-year period. Relatively too little early and too much late in the period. (From Thorndike, *op. cit.*, p. 166.)

such as getting the meaning of the whole, observing the development of the thought, and the recurrence of similar ideas—are more adequately secured. The sectional

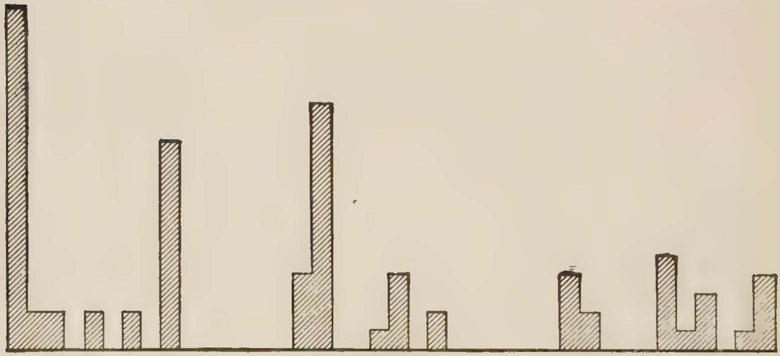


FIGURE 35. Distribution of practice on 72, 73 . . . 79 ÷ 8 or 9 over a four-year period. An irregular distribution with gaps that are too wide. (From Thorndike, *op. cit.*, p. 167.)

method often enlists more artificial connections, such as those with position in each stanza. These may later be the source of confusion, since the first lines of several

stanzas are recalled on the basis of being in first position. The part method introduces certain misleading bonds. For example, when the first stanza is finished, the learner goes back to the beginning of the same verse with the result that the end, instead of being connected with the beginning of the next stanza is connected with the beginning of the first. Hence children often get "stuck" at the beginning of a stanza which they can recite readily

FIGURE 36. Distribution of practice in multiplication with certain 3-place multipliers. Relatively too much practice at the beginning and too wide intervals between reviews, since the distribution covers a four-year period. (From Thorndike, *op. cit.*, p. 162.)

once they can secure a start. The main advantage of the whole method, then, lies in the fact that the connections are formed in the way they will later need to function. This, with the advantages secured by the length of the lesson and the better distribution of repetitions, makes the whole method, in general, a more economical method of study.

Many investigations, in terms of the amount of time required to learn, have borne out the advantage of the whole method. A sample result is shown in the accompanying table.

WHOLE VS. PIECEMEAL LEARNING OF POETRY (FROM PYLE AND SNYDER)

NUMBER OF LINES	PART METHOD TIME TO LEARN	WHOLE METHOD TIME TO LEARN	PERCENTAGE OF TIME SAVED BY WHOLE METHOD
20	16′ 12″	14′ 17″	12
30	27′ 23″	23′ 53″	13
40	38′ 44″	35′ 16″	9
50	48′ 31″	43′ 53″	12
60	81′ 10″	63′ 38″	22
120	168′ 55″	139′ 35″	17
240	431′ 20″	348′ 00″	19

On the whole, the advantage of learning by going through the material from beginning to end each time is greater for the long than for the short lessons.

The whole methods show its superiority in recall some time after the original learning more conspicuously than in the saving of time in the process of fixation. The following table is illustrative:

RECALL OF POETRY LEARNED BY WHOLE AND PART METHOD (FROM LARGUIER DES BANCELS)

LEARNED BY PART METHOD		LEARNED BY WHOLE METHOD
	NUMBER OF WORDS RECALLED AFTER ONE WEEK	
26.6		40.6
	After two years	
6.4		16.6
	Per cent recalled after two years	
24		40

The whole method shows to advantage in memorizing poetry, prose, vocabularies, lists of words, and non-sense syllables—and probably in most materials which are to be memorized in serial order. In learning by reading (history, etc.), the relative merits of whole and piecemeal methods have not as yet been demonstrated, but it is probable that reading a lesson through as a whole is distinctly advantageous.

Either in memorizing or reading, the whole procedure

should not be adhered to slavishly. Difficult and important sections should be given more attention; easy or unimportant matter "skimmed."

Complicated dance steps, musical selections to be played or sung, and many industrial operations fall within the serial type of learning which may be learned as a whole or in parts. In an inventory of methods actually used by one hundred prominent musicians, fourteen reported that they employed the whole method exclusively, another fourteen combined the whole and the piecemeal procedure, while the remaining seventy-two learned mainly bit by bit. These data throw little light on the merits of the methods inasmuch as highly competent performers in every field often employ uneconomical methods. Crucial investigations in the case of such functions are lacking. Theoretically, the whole method would seem to possess the same merits here as in the case of memorizing poetry or prose.

Peckstein, however, found that in learning certain motor acts, such as tracing the course of a complex pencil maze while blindfolded, the whole method was uneconomical. When the task was extremely difficult, subjects were sometimes unable to learn at all by the whole method. These findings illustrate the risk involved in widespread applications of facts found in one field to situations encountered in others. We must await the results of further investigations to determine the relative merits of the whole and the part methods in the field of motor learning.

Confusion Resulting from a Change of Method.—In the previous chapter, the unwillingness to change well habituated methods of learning or performing and the discomfort frequently occasioned by variations from usual procedures was mentioned. To attempt to read or

memorize more rapidly, to learn by distributed rather than by concentrated practice, or by the whole instead of the piecemeal method, or to adopt some other new device may lead to temporary difficulties. Chagrined by the failure of improvement to appear at once, students frequently abandon the new method as futile. Temporary confusion and often loss of efficiency should be expected. The novel procedure must be habituated before full returns may be enjoyed.

QUESTIONS AND EXERCISES

1. Explain why learning to read German does not enable us to write it or to understand spoken German. Would it be wise to learn in one way or another according to our need to read, write, speak or understand it when spoken?

2. Why is it that some people have difficulty in understanding a passage when they read it aloud to a group?

3. Why is it that a person's voice often sounds quite different when (a) reading aloud, (b) reciting, (c) just talking?

4. How would you teach a child to write English compositions? Show how the principles offered in the chapter apply?

5. Would it be worth while to have the child copy good compositions written by others?

6. Can you offer any example of the use of "crutches" in the learning of the school or everyday life? Of the formation of irrelevant habits?

7. Would you present in the spelling lesson the common misspellings of difficult words along with the correct form? Would you say to a child, "You wrote *meashure*. The correct spelling is *measure*," or simply say the word was misspelled and give the correct form?

8. Try this experiment on three different groups. Ask them to guess the length of time which passed between signals. You will say "Ready!", and in a moment "Now!". Then allow an interval of 10 seconds, at the end of which you again say "Now!". The members of the group then write their estimate of the interval in seconds. Repeat with other intervals such as 6, 8, 15, 14, 10,

18, 9, etc., until 30 trials have been made. With a second group, use the same intervals and the same number of trials, but after each trial say: "The time was more than 10 seconds" or "less than 10 seconds" as the case may be. To a third group, state the exact length of the interval after each trial. Compute the improvement for each group. Compare and explain the results.

9. Should the writer attend to the feelings in the fingers or the written product? The singer to the "feel" in the throat or to the vocal product?

10. Should the learners be taught to criticise themselves? Why? How may this be done?

11. Taking into account the facts concerning recitation vs. rereading, the distribution of intervals in learning and review, the whole vs. the part method of study, plan the most effective method of study for this course in psychology.

12. Can you see any advantages in taking but few notes during a lecture and writing out a full account later, in comparison with taking very full notes during the lecture and reading them over later? Could you test these or other methods experimentally?

13. Would it be best to have children begin writing by (a) tracing in a groove, (b) tracing in the air, (c) making ovals, loops, etc., (d) tracing letters seen through tissue paper, (e) copying letters, or (f) words?

REFERENCES

W. H. Pyle, *The Psychology of Learning* contains a bibliography of the general studies on the economy of learning.

In G. M. Whipple, *How to Study Effectively,* 1916, will be found many useful suggestions.

The psychology of learning in the case of the several school subjects is treated by F. N. Freeman in *Psychology of the Common Branches,* 1916; Daniel Starch in *Educational Psychology,* 1919, chapters 15-21 inclusive; E. H. Cameron in *Psychology and the School,* 1921, chapters 16-19 inclusive; and E. L. Thorndike in *The Psychology of Arithmetic,* 1922, the introduction and chapters 1-8 inclusive.

CHAPTER XIII

THE ACQUISITION OF PERCEPTS AND IDEAS

In the two preceding chapters, in which the characteristics and economical methods of learning in the case of writing, spelling, reading, arithmetic, and other complex functions were considered, it was apparent that what may superficially appear to involve little more than "drill" or memorizing, may and often does enlist the higher mental processes of analysis and reasoning as well. Modern educational practice especially seeks to utilize, encourage, and develop both interest and ability in independent thinking, problem solving, reasoning, and imagination. It seeks, moreover, to do more than merely develop ability to think and reason in arithmetic or grammar; it seeks to train capacities more widely applicable, to develop abilities to reason in the situations of life whenever encountered and whatever the type. In considering these forms of training, three general problems are encountered. The first problem deals with the data, the content, the stuff of which thought is composed, and the ways in which the substance of thought is acquired. We must answer the question: How are ideas and concepts usually acquired, and how may they be most economically and effectively developed? The second problem is concerned with the mechanics or technique of thinking, reasoning, and problem solving. Here we shall try to answer the questions: How do we think and how may we improve our thinking in a particular field? The third problem

concerns the general effects of specific training. Here will be encountered such questions as: If children are taught effectively to study, to reason, to exercise initiative and originality in grammar or arithmetic, to what extent will this training carry over or transfer to other fields, such as those of law, medicine, or business affairs? By what methods may the greatest transfer of training be achieved?

In thinking, reasoning, and imagination we are dealing with recalled facts. *How* we deal with them will be considered in the following chapter. For the present, we will be concerned with the various types of recalled facts and with the way in which they are acquired.

The Relation of Percepts and Ideas

Facts, in the first place, result from sensory perception. They are the outcome of visual, auditory, tactual, and other sensory experiences with things and events. Typically the percept, which as we have previously observed is a complex conscious reaction, is built up by reacting consciously to many stimuli acting at once. For example, a child on its second birthday is presented for the first time with a puppy. At first the little dog is perceived in a variety of ways. It is a small dark thing which runs about—sometimes dangerously near—with four legs; a thing which barks, whines, scratches the door, and sounds "pat, pat, pat, pat" when it runs; a thing which likes to eat and frolic. Gradually these various conscious reactions become connected with many different stimuli, so that to any one stimulus a joint response, the percept, may occur. Thus, when the child sees only a head or a tail, hears a bark, a whimper, or "pat, pat, pat" on the floor, or feels a moist nose or a shaggy back

against his hand, he promptly becomes aware of the puppy.

If we observe the child's behavior *in the absence* of the pet, we shall discover good evidence that he is thinking about or has an idea of the puppy. A visitor is given a detailed description of the visual appearance, the weight, bark, and other characteristics of the dog. The child reports occasionally that he dreamed about his dog or that he imagined his pet doing new stunts, such as standing on its head or climbing a tree. In these cases, the child obviously has an *idea* of the animal. He is aware of the dog's characteristics when the dog is really absent.

The awareness of any thing, event, or fact when it is not present to the senses we shall call an *idea*. We can think of a great variety of objects, such as dogs, cats, houses, books, men, and other facts which we call objects. We can think of musical selections, spoken words, pain, accidents, a sore throat, a struggle with an umbrella, an act of courtesy—any fact, experience or event may be recalled given the proper stimulus, which is always, either another percept or another idea.

Trial and Error in the Acquisition of Percepts and Ideas

The child's idea of the puppy is a complex conscious reaction which is constantly undergoing change by additions and subtractions of the elements which constitute the whole. In this development of the percept the trial and error form of learning is apparent. The child at first perceives the animal and proceeds to deal with it much as he would with other objects with which he is familiar. He observes legs somewhat like those of his toy chair, and seizing a leg by which to carry the puppy about, the

child's idea is modified by the painful consequences. If the child squeezes the puppy too affectionately, as he might a stuffed animal, the yelp or possibly a snap results in the elimination of part of the old way of perceiving the pup, and the addition of new factors. The dog, in the course of time, is perceived and thought of as an object with sharp teeth, a certain weight, great strength and agility, a thing that mustn't be stepped on or immersed in water, which barks at birds, snaps when disturbed in feeding, and never talks, but is generally a playful companion. The child's idea of a dog is a changing, growing complex of particulars.

Analysis and Combination in Perception

In the development of percepts and ideas, two processes are going on simultaneously. The complex object is, on the one hand, analysed; the minute and subtle features are perceived. Little details of the dog's appearance and behavior are noticed. The shape of the pup's ears, the number of toes, the significance of slightly different whines and barks, the characteristics of its fears and angers are observed more and more specifically. Perception, and consequently thought, becomes progressively more detailed and refined. At the same time, a process of synthesis or building up is apparent. Perception and thought become not only more refined, but also more broad and inclusive. The minute facts become combined into percepts and ideas more rich and comprehensive. Analysis and synthesis go on simultaneously and continuously so long as the child continues to disentangle new features of dog-ness, so long as he continues to observe new details. If, as a young adult, he undertakes the study of anatomy, physiology, or biology, his percepts

and ideas of a dog will become greatly enriched. From the childhood idea of just-something-surrounded-by-skin, the dog's body will be thought of as an amazing complexity of intricate organs and functions.

Various Types of Perceptual Learning

Perception of the Printed Page.—The vitally important characteristic of human conscious reaction is its analytical character, the capacity to become aware of very subtle and obscure features of things and events. This page of print, to the infant, is merely a vague confusion of black and white. Some day, after a good deal of experience, it will be found to contain words, although the words at first will be perceived and consequently thought about as vague wholes. Later, the words will take more definite form, become associated with objects, and be reduced to word units, letters, or phonograms like *ing, ank, ock.* As analysis proceeds, the immediate perceptions and ideas of words are changed; the word becomes a different total from what it was at the beginning.

Perception of Spoken Words.—In the perception of spoken words, we find the same processes of analysis. The child at first hears an unintelligible jargon of sounds whose significance is less than that of a foreign tongue to an adult, although even the adult is usually unable to detect words, or even sentences as such, in an unusual language. The child probably first realizes that the sounds are either directed to him or elsewhere, that their general tenor is friendly or otherwise. Gradually the frequently repeated sentences or phrases become associated with acts or objects such as food or play; later, words become appreciated as such; and eventually, fine distinctions, grammatical forms, and usages, the meaning

of certain intonations and inflections are understood. The perceptions of effective oral speech may, indeed, become a fine art, to which a life-time may be devoted, as in the case of the teacher of oral expression, the dramatic critic or impresario.

Perception of Facial and Bodily Expressions.—The perception of the significance of the facial and bodily "expressions" is an important feature of all human learning which illustrates again the analytic character of the process. Father appears from his day's labor at the office with an expression which mother at once perceives and takes into account, modifying her words and deeds accordingly. The child fails to notice the rather obscure scowl, but when his joyously noisy behavior is met with a sudden reproach, he is forced to a more careful survey of the situation. After many trials and errors, the child learns to perceive a variety of rather subtle features. The learning is slow, however; the average child is five or more before he can, for example, identify the characteristics which distinguish ugly from the pretty faces, and probably considerably older before the less conspicuous evidences of anger, pleasure, annoyance, or sadness are perceptible. In these forms of social perception, the child learns very much more readily than his dog. The latter, doubtless, never perceives beauty or ugliness, the facial expression of scorn or sorrow, although various bodily movements which precede a kick or blow, or the provision of food, etc., are singled out. The degree to which social perception extends among human individuals appears clearly enough in instances which show an unusual lack of it. The individual who does not realize that he is boring when he means to be interesting, amusing when he thinks he is impressive, offensive when he tries to be complimentary, or who does not observe that he is un-

welcome in a group, portrays one of the most striking failures of perceptual learning. In part, failures in social perception are due to inability to observe one's self. It was found in an investigation in which each one of a group of college girls judged each of her acquaintances as well as herself for various traits, that those generally recognized by others as the most snobbish, vulgar, or conceited were very poor judges of themselves in those respects. They apparently did not perceive, as others did, in their own words, deeds, and expressions the elements of the undesirable traits. Similarly, those who possessed the least refinement, intelligence, sociability, humor and neatness were rather blind to their deficiencies. They possessed, moreover, inferior ability to perceive these characteristics in other people. Having never perhaps achieved clear ideas of what constitutes sociability, neatness, refinement, etc., either in themselves or others, the process of learning came to an early halt. They were like the child learning to write or speak without a distinct model to utilize in discovering successful and erroneous reactions.

There are a number of rationalized or commercialized methods of character perception, simple lessons by which one is able, supposedly, to learn how to perceive various fundamental traits, honesty, intelligence, or executive ability, by observing features of the face, head, or other physical traits. To be saleable, such systems are often very simple, too simple in fact to be sound. Usually they are useless; often misleading. The really important signs by which competent judges of human ability and character are guided are far more subtle than the color of the eyes, breadth of the forehead, shape of the nose, prominence of the chin, and the like. They are, in fact, usually too subtle to identify readily. Elements of speech

and significant manners, the physique, facial expression rather than features, dress with all of its intricacies of style, neatness—all of these and many other traits may be involved in the perception of character. Very frequently it happens that the meaning of each of the many possible characteristics is not well singled out as such. One simply concludes, without analysis—that is, on the basis of many factors acting at once—that this man is trustworthy or not, or that he will make a good, average, or poor clerk.

"Intuition."—When the various features upon which perception is based are not individually understood as the result of conscious analysis, the term *intuition* is sometimes applied. "I know by intuition that that man is not altogether trustworthy." "I dislike that man, but just why I do not know." "I feel as though I were catching cold." "Something tells me that it is going to rain." These are representative statements of common situations in which we perceive, but do not know by what particulars the percept is occasioned. Sometimes it is an obscure feature, such as a curious look about the eyes or mouth, which suggests dishonesty; sometimes many stimuli acting together—such as various unlocalized sensations from the body which result in the impression of impending illness, or the unanalysed effects of dampness, chilliness, and other atmospheric conditions, may occasion the idea of rain.

Perception of Distance.—In a number of instances in which practised individuals have been unable to discover the factors by which their percepts of objects or conditions were determined, careful research has resulted in an analysis more or less complete. One of the best examples is the disentangling of the process of perceiving the distance of an object. The child or adult, of course,

seldom gives a thought to the means employed in observing the relative distance of objects. He simply sees that one thing is near, another far. The process is quite as "intuitional" as those processes of the less usual character just mentioned. The preferable statement is that all intuitions are percepts. The fact that perception of distance or depth is complex and the factors involved unanalysed will illustrate the similarity of the two.

When the eye is exposed to the light waves reflected from a landscape, an image is formed on the retina much as it is formed on the plate of a photographic camera. It is a flat image, without depth, the third dimension of space. The individual, of course, really *sees* with his brain, although the activity of the eye is an essential step in the series of events, and he sees things at different distances, not as if painted on a flat canvas. The percept of some things near and others far, which may be made almost instantly, is based on a number of very subtle stimuli, acting simultaneously. The more distant the object the smaller the image cast on the retina; partly cut off from view by intervening objects, the distant objects are less clear in outline and detail; they are washed out in color, taking on a bluish or purplish hue and lacking the reds, yellows, and other warm tones of near objects; shadows cast by distant objects appear less distinct and of different shape than those nearby. The right eye gets a somewhat different view of near objects than the left, since they view from slightly different angles. The effect is greatest for very near objects and becomes less until at a distance of three or four hundred feet the differences are negligible. These factors, and possibly more, operate with the eyes and head motionless. Movements of the head yield other data inasmuch as near objects seem to move in a direction opposite that of the head,

while distant objects follow the head-changes which are easily observed during rapid movement, as when one is riding in a train. All of these factors may operate together to determine one's ready perception of depth. Some of them are very subtle details and their interrelations are complex.

A great many human percepts are equally complex and equally difficult to dissect. In much the same way that we find ourselves able to speak, write, or ride a bicycle without knowing very well how we do it—much less how we learned—we find ideas with which we may think, with little, if any, inkling as to how or when the facts were acquired, and we perceive characteristics of objects and events without knowing how the percept was acquired. The same laws of learning and reacting seem to hold in the perception of trees, men, songs, beauty, symmetry, distance, weight, honesty, sin, shape, and other situations as were found in motor learning. One characteristic of perceptual learning, its analytical character, should be followed through in greater detail with special reference to the acquisition of abstract notions.

The Acquisition of Abstract Ideas

John is a particular boy; but he may be perceived as made up of many qualities or characteristics such as height, weight, color, flesh, hair, honesty, strength, intelligence, etc. The dime which you see on the table is commonly said to be a *concrete* or *particular* object; but perceptually it may be analysed into brightness, roundness, metal-ness, hardness, solidity, value. We can learn to perceive each of the qualities, and what is perceived may later be the object of thought. An interesting, and certainly a tremendously important, human characteris-

tic is the capacity after sufficient and proper experience to learn to think of many of these qualities quite independently of the setting or situation in which they have been perceived. We can come to experience an idea of roundness, hardness, area, or honesty, without thinking of the concrete situations in which the qualities have been observed. The character has been torn out, disentangled, abstracted from the other details among which it has been perceived. Such ideas are commonly called *abstract ideas.*

Illustrations of Abstractions.—Inasmuch as one of the important tasks of education is the development of abstract ideas, and inasmuch as such ideas are most important materials of thought, it will be advisable to ascertain as fully as possible the principles involved in such learning. In arithmetic one, two, and other numbers; sum, difference, remainder, product, and average; add, subtract, divide, and multiply; percentage, discount, interest, profit; length, width, height, area, and volume are not real objects in the ordinary sense, but elements or aspects which may appear in countless different situations. In other subjects we encounter such concepts as noun, verb, subject, predicate, object; soft, hard, big, little; triangle, circle, square; above, beside, without; north, south; if, why, how, nevertheless. Honesty, fairness, right, wrong, sympathy, liberty, justice, government, law, order,—these are facts which do not exist in the child's experience until ideas of them are laboriously acquired.

The process of development of many abstract ideas requires several years. An average child of three or four can correctly perceive a large number of objects such as a key, knife, watch, pencil, various animals, fruits, and so on, but he is usually five before he understands cor-

rectly *heavy* or *light*. He is six before he has abstract notions of *right* and *left*. Not until past eight does he realize the meaning of, or take much interest in, abstract *differences*, such as the difference between a fly and a butterfly, or an egg and a stone. Not until twelve is the child able to define such abstract words as *pity, charity, revenge, justice*. Previous to this year, the average child may have been taught to express pity and to act charitably, but the idea has not been thoroughly abstracted. He may, too, have been taught verbal definitions of some of these terms without really having the idea in abstract form.

The Need of Many Situations Containing the Abstract Element.—To provide the proper conditions for abstracting a character, it is necessary to present a large number of different situations which contain the element. When the abstract quality is given in but one situation, or but few situations, the dissociation is seldom complete; the element remains imbedded in the larger unit. A mother had attempted to teach her child the meaning of square by presenting the top of a box which was displayed while the word "square" was repeated and explained. When the father was told of the lesson, he held up a paper, asking "What is this?" "A paper," was the response. "Yes, but what kind of a paper?" "A white paper," etc. No effects of the lesson could be secured by the use of cards and other objects, but when directly asked "What is a square?" the child ran to the box, exclaiming proudly, "That is a square." The element squareness had not been abstracted. It was not known as such but only rather vaguely as a feature of the box situation. To develop the idea of squareness, one must show the child many different gross totals which contain it, such as a square card, a square desk, a square block, a

square board, drawing, picture, etc. When many different situations are presented, the squareness element cannot be easily or immediately associated with them all, and it is unlikely that it will become associated with any one since it is so slightly connected with each. As the other features, let us say the "boxness," "paperness," "rugness," etc., become more numerous, each is so weakly connected with "squareness" that none is likely to be recalled —a fact more easily shown by a few diagrams.

Think of each of these gross totals as including but two elements, a "squareness" element and a "thingness," i.e., "box-ness" element. Actually, of course, the learner is dealing with many more than two elements. Suppose that we repeatedly present but one square object, a box, to which the responses are squareness and boxness. Then, according to the familiar principle of associating two stimuli together, each response becomes more and more strongly attached to each other stimulus, as is shown here:

AT FIRST

$$\begin{tikzcd} \text{Situation} & \text{Response} \\ \text{Boxness} \arrow[r] \arrow[dr] & \text{Awareness of boxness} \\ \text{Squareness} \arrow[r] \arrow[ur] & \text{Awareness of squareness} \end{tikzcd}$$

LATER

$$\begin{tikzcd} \text{Boxness} \arrow[r] \arrow[dr] & \text{Boxness} & & \text{boxness} \\ & \text{Squareness} & \text{squareness} \arrow[r] \arrow[ur] & \text{squareness} \end{tikzcd}$$

What we have done here is to combine the two reactions rather than isolate them. What we want, however, is not combination but dissociation.

Now, consider the next procedure, in which many square objects are presented one after another. On the

left is a diagram of the connections in each of three cases; on the right a summary of these connections.

THE CONNECTIONS FORMED WHEN THREE OBJECTS ARE USED

SITUATION	RESPONSE
See box →	think box
See square →	think square
See map →	think map
See square →	think square
See rug →	think rug
See square →	think square

TOTAL NUMBER OF CONNECTIONS	
See square → think box	1
See square → think map	1
See square → think rug	1
See square → think square	3

THE CONNECTIONS FORMED WHEN ONE HUNDRED OBJECTS ARE USED

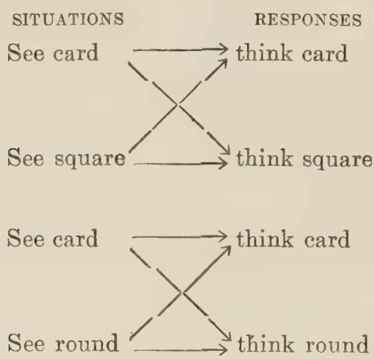
Square → object 1, one connection
Square → object 2, one connection
Square → object 3, one connection
Square → every other object, one connection
. . . .
Square → square, 100 connections

The square to square connection, however weak at the start, is gradually growing stronger without being attached consistently to any one other irrelevant response. When one hundred objects have been presented, *squareness* tends to connect slightly and about equally to each and every object, but it tends to lead to the idea of squareness more strongly since that connection has received one hundred times as much exercise as have the other connections. In this practice, however, there is no principle actively operating toward dissociation. All that

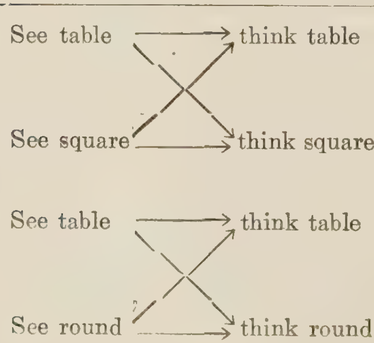
we are doing is to give the square → square connection the advantage over others by a preponderance of exercise.

The Use of a Contrasting Abstract Element.—Another form of association of elements provides directly for dissociation. It consists in presenting a situation which contains the abstract element *squareness* along with a similar gross situation which contains an *unlike* or *opposite* abstract element. For example, present at the same time a square card and a round card; a square table and a round table; a square tin and a round tin; and so on.

The connections formed are shown in the accompanying diagrams:



PAIR I.



PAIR II.

SITUATIONS		RESPONSES
See tin	⟶	think tin
See square	⟶	think square

PAIR III.

SITUATIONS		RESPONSES
See tin	⟶	think tin
See round	⟶	think round

If we sum up the number of times each S-R connection, for which the stimulus is square or round, illustrated above, is exercised, we get the following:

SITUATION		RESPONSE		SITUATION		RESPONSE	
square	⟶	square	3	round	⟶	round	3
square	⟶	card	1	round	⟶	card	1
square	⟶	table	1	round	⟶	table	1
square	⟶	tin	1	round	⟶	tin	1

The outcome is the same as before, except that we have both round and square. But consider the following connections which appear also in this case:

SITUATION		RESPONSE
See card	⟶	think square
See card	⟶	think round
See table	⟶	think square
See table	⟶	think round
See tin	⟶	think square
See tin	⟶	think round

The object tends to lead both to square and round which are, of course, mutually exclusive ideas. The re-

sult is that they tend to nullify each other, leaving the ground clear for the square → square and the round → round connections.

The square → square and the round → round connections would here be far stronger than any others, partly because they receive so much more exercise, and partly because each object is connected both with round and square, contradictory tendencies which tend to neutralize each other. The result is that in the course of time the child is able to recognize squareness and roundness in almost any situation in which it appears; and furthermore, he is able to think of square and round without recalling the particular situations in which they were encountered. His idea is that of an abstracted feature, quality or relation.

Some Practical Suggestions

From the analysis of the process of acquiring abstract ideas, several suggestions follow.

Attention to Details.—Direct and encourage the pupil to attend to the significant details. This may be done by pointing out, illustrating, emphasizing in speech, or otherwise calling attention to the element at the start. One should try to prevent attention from becoming dispersed over the object in a general way or from becoming attached to some irrelevant detail.

The Choice of Gross Situations.—Select gross totals in which the elements in question are as obtrusive as possible and encumbered by as few irrelevant details as possible. The circles or squares should be real circles and squares, not approximations. If you are trying to illustrate justice or honesty, they should not be confused with a number of other irrelevant ideas contained in the story or illustration.

The Avoidance of Irrelevant Details.—Care should be taken lest some other irrelevant element invariably accompany the one in question. For example, squareness should not always be presented in the form of *solid* objects, such as boxes, boards, etc.; it should sometimes be outlined on a paper or on the board, otherwise squareness may always mean a *square solid.* In teaching the meaning of noun, consider these two procedures:

A.

The bird sings.
A dog runs rapidly.
Her dress is brown.

B.

The horse is large.
Where is my pencil?
Please get the umbrella.

A is ineffective because the noun is always the subject of a sentence. If the child received only this form of drill when presented with the sentence: *Who has my book? who* rather than *book* would probably be called the noun. In B, this error is avoided since the noun occurs as object as well as subject, and at the end as well as at the beginning of a sentence.

Providing Abundant Experience.—A clean-cut abstract idea is usually achieved only as the outcome of wide experience. Children may learn to act in a kindly or honest manner in a number of situations, or to add or to use the number two on many occasions, without really acquiring the abstract idea involved. The following definitions, given by children of twelve or above, illustrate inadequate notions of the real meaning of *justice.* "It means a court"; "It's the Court House"; "It

means to have peace"; "to be kind"; "to be honest"; "to do right"; "to get punished." When children have such ideas as: "to multiply always means to make bigger"; "weight is what is in things to make them fall"; "adverbs are what end in -ly"; the analysis has obviously been incomplete. The idea of a number—2, 3, 4, or 5—includes many significant features which must be discovered before the notion is adequately abstracted. The number *four* means in certain instances a collection of four particular items—hats, men, or tops. To know the meaning of four in this sense is to have an idea of the collective feature, and the ability to perceive the four-ness of any collection of this size. Four may also mean a stopping place in a series. Thus the child may count 1, 2, 3, 4, and four-ness in this serial sense may exist apart from the collection meaning. Four, again, may mean a position; it is the number between three and five. It may also mean a relative size; thus if —— is one ———————— is four. Four may also mean half of eight; twice two; one plus three; seven minus three; the square of two; the square root of sixteen; the cube root of sixty-four; and so on. The idea of four is thus a growing concept built out of experience in which analysis must occur before combination into more meaningful units of thought may be achieved. Well arranged and rich experience is quite essential. Difficulties in thinking experienced, for example, in solving problems in arithmetic often rest upon deficiencies in analysis of many elementary factors, upon insufficient experience in some directions, and upon total neglect of others.

The Use of Rules, Definitions, and Other Verbal Explanations.—A popular method of attempting to abridge the process of acquiring ideas has been to make abundant use of theories, explanations, rules, reasons, definitions,

and other formulæ, presented in words, written or spoken. Verbal definitions of roundness, acute angles, or honesty; explanations of why "honesty is the best policy" or why we "carry" in addition; the use of axioms in geometry from which particular facts are to be discovered by deductive reasoning; the rules and definitions in physics and grammar—these are instances of this general practice. Older text books in spelling, arithmetic, grammar, history, geography, and other subjects were packed with such verbal formulæ as: "*Gravity* is the accelerating tendency of bodies toward the center of the earth"; "*Justice* is the rendering of what is due or merited"; "A *fraction* is a quantity less than a unit or one expressed as the sum of a number of aliquot parts"; "A *preposition* is a part of speech that denotes the relation of an object to an action or thing"; "An *angle* is that relation of lines which is measured by the amount of rotation necessary to make one coincide with the other."

The Deductive Method.—Most of these formulæ are verbal formulations of an abstract idea. The pupil, supposedly, having learned the formula, could apply it to particular instances by logical deduction. With a minimum of practice in application, the abstract idea supposedly would be clarified and henceforth generally applicable to any particular case. This has often been called the deductive method of teaching which has been used widely in mathematics, geometry, grammar, and science.

Several difficulties have been encountered in attempting to lead from the verbal formula to the particular facts. Often the definition or rule when given at the start is meaningless to the pupil. The adult understands the formula because it is a summary or general statement of the essence of the particular facts with which he is already familiar. No less serious, but more easily remedied, are

the difficulties presented by the use of words and linguistic structures that are beyond the learner's comprehension. Many of us have had the experience of suddenly realizing in our twenties, or later, the meaning of definitions, rules, or poetic gems about Truth that were learned in our teens. A formula which cannot be understood because of the pupil's inexperience with the related facts, or because of linguistic difficulties, will, of course, fail to function. Even when the verbal principles are clearly and intelligibly phrased, it requires skilful teaching to make them function. There is a tendency on the part of both the teacher and the pupil to test real understanding by noting the accuracy with which the rule or definition is cited. The teacher may assume that knowledge of the axioms in geometry, of the general laws in physics or the rules in grammar or spelling is satisfactory evidence of the mastery of the facts. The pupil, seeking the line of least resistance—as most of us do in learning—finds it easier to memorize the definitions and rules than to understand the details. The verbal expressions thus become ends instead of means and merely form an additional burden.

The Inductive Method.—Perceiving these objections, teachers sometimes go to the opposite extreme, utilizing what is called a purely inductive method in which the principle or the abstract idea is not presented verbally until very late, if at all. The pupil is required to abstract the rule or general truth by himself, if he can. Thus, spelling, arithmetic, grammar, moral habits, and the like are taught entirely by means of specific experiences. Such a spelling rule as "*I* before *e* except after *c*, or when sounded like *a* as in neighbor or weigh," or such an arithmetical definitions as "Multiplication is the process of taking one number as many times as there are units in

another," or the explanation of "Honesty is the best policy," together with memorization of the sentence, is considered essentially futile.

The Combined Method.—Both practices, that of extreme dependence upon verbal formulæ and that of complete or nearly complete disregard of verbal explanations, are inadvisable. While concepts stated in words cannot replace real experiences, and while they are often clumsily framed and unwisely used, verbal generalizations and definitions may be very fruitfully employed. Their usefulness is, of course, the only real test. The reaction against rules and definitions has developed from the discovery that most of the rules in common school use were of no real service. But with simplicity of linguistic construction and accuracy in describing the facts, the proper utilization of verbal formulæ will be of appreciable service.

The time at which a rule or principle should be introduced is a matter of importance. It is impossible to give a definite statement in terms of the point in the process, beginning, middle, or end, at which the definition should be introduced with best effect. *The essential requirement is that verbal generalization and specific experience should interpenetrate.* Sometimes the definition or principle should be introduced at the very start, as when previous experiences afford a partial understanding. Usually the generalization must be delayed until experience has been sufficient to make the principle partly intelligible. It should come at a time when it will to some degree illuminate the particular facts of which it is a summary or generalization and when it will be illuminated by them. Introduced too early, it is likely to be learned by rote independently of the particulars; introduced too late, its explanatory function can be only partly fulfilled.

Generalization and experience must develop together, each enriching the other.

The facts may be illustrated by an experiment by Judd and Scholckow, in which verbal explanations of the abstract theory of refraction were found to assist in clarifying the idea and in making it practically applicable. The practical test was success in learning to hit a target placed under water. One group of boys was given practice with a target under twelve inches of water, along with explanations of the theory of refraction; another was given practice without the theoretical explanation. For some time both groups did about equally well. The theory seemed to be of no value in the first series of tests—perhaps because it was introduced too early, or because it was unintelligible until it became clarified in the light of experience. But later theory and practice did fuse, with the result that the first group not only "got the idea" of refraction to some degree, but also made more rapid strides in accuracy in throwing at submerged targets, especially when the depth in the water was changed. While the effect of verbal explanations alone was not tested, it is probable that by this single means, just as by experience alone, the idea of refraction would not have been developed so effectively as by the two dynamically combined.

The failure of rules, definitions, explanations, and other formulæ to function may be attributed partly to the use of the wrong kind of formulation or to use at the wrong time. Definitions and explanations must keep pace with the growing idea. They must, like the idea, develop gradually. We cannot begin with a final technical definition of a fact, any more than we can begin with full-fledged knowledge of the fact. Early explanations must be incomplete if the general ideas—whether of pa-

triotism, evolution, gravitation, or multiplication—are complex and long in developing. Definitions should be enlarged to fit the experience then occurring or which has just occurred. The final and quite comprehensive formula comes near or at the end, serving to sum up the whole experience or to throw in relief its essence.

The Acquisition of Ideals

Among other abstract ideas, honesty, trustworthiness, justice, fair play, loyalty, mercy, and the like have been included. The term *ideal* is used in several senses, but most commonly to embrace the idea of the characteristics of honest, loyal, or merciful behavior plus an impulse to act in the characteristic way when the appropriate situation is provided. The impulse to action is subordinate to the perception or idea, in the sense that an individual cannot *generally* act honestly unless he is aware of what constitutes the honest course of action. The development of honesty in behavior, then, is in part dependent upon the development of the ability to perceive what we may call the honesty element in various situations. A clear idea of honesty is acquired in the same way that ideas of squareness, angles, four-ness are arrived at by analysis and eventual abstraction. The learner is assisted as before by meeting the "honest" feature of many different situations, by an analytical attitude, by having the element pointed out and emphasized, by contrasting it with dishonesty, by verbal explanations and formulations. As in the acquisition of other facts, honesty will not be thoroughly understood or dynamically effective by verbal instruction or deductive exercises alone, nor will the idea be most clearly acquired by experience alone—the two are acquired together, each supplementing the

other. Ideals become effective impulses to action, when the idea is clearly perceived and followed by action with a satisfying effect. In moral training, each of these features must be developed—the perception of the moral quality and the doing of the moral act, followed by a satisfying state of affairs. When experience has been sufficient to enable one to perceive the moral aspect, as we perceive blueness or roundness in any situation, and when the percept or idea is followed by the impulse to act accordingly, we have the ideal in dynamic form.

Children occasionally act in an inappropriate manner because they do not perceive the proper line of action; their idea is incomplete and inapplicable to some situations. For example, many seven-year-old pupils, in answer to the question: "What's the thing for you to do if a playmate hits you without meaning to do it?" give such answers as "Get even"; "Tell him to 'cut it out' "; "Tell my mama"; "Not play with him" or otherwise show a failure to perceive the essential moral feature of the situation. To extract the proper moral quality is not of itself a guarantee of proper action, but it is a desirable antecedent.

An Experimental Study.—An experimental study by Voelker gives an illustration of the simultaneous development of moral ideas and moral conduct. Six groups of about a dozen boys each, of ages ten to fourteen, were first given a series of ten tests which offered an opportunity for either trustworthy or untrustworthy behavior. Situations were provided offering the boy an opportunity to keep over-change, to steal, to cheat in an examination, to tell a secret, to make false claims, etc. Each test provided a real temptation; dishonesty would be rewarded by some immediate personal gain. The boys, of course, were unaware that the temptations were pre-arranged.

In the first trials, the temptations were effective in various degrees, ranging from untrustworthiness in eight out of ten tests to one out of ten; only one boy was one hundred per cent honest. The average boy proved susceptible to three or four of the ten tests.

During a period of seven weeks, two groups were given intensive training, which embraced the learning of codes of trustworthiness, Boy Scout oaths, lectures, and an abundance of cautions, exhortations, encouragement, and explanation during games, examinations, hikes, group meetings, and other Boy Scout activities. Rewards and punishments were administered as occasions made them advisable. In short, the leaders of the two groups attempted by many devices to develop and clarify the notion of trustworthiness, to develop ability to see it in many different situations, and to form habits of acting in a trustworthy way.

Two other groups were given the ordinary Boy Scout training in which, presumably, less effective interpenetration of verbal instruction and experience was obtained and the development of trustworthiness was less deliberately designed. Two other groups of school boys were given no Boy Scout training, and no special training in trustworthiness. At the end of the seventh week, the six groups were again put through a series of ten tests which were new in material but in general type similar to those of the first series. The two groups systematically trained in trustworthiness improved the most; the two untrained schoolboy groups the least; with the regular Boy Scout group about midway. The specially trained group did not achieve perfect trustworthiness, however. They were guilty of untrustworthy acts, on the average, in about two out of ten tests. Some of the failures probably were due to inability to perceive the right clearly,

while others were instances of seeing the right but doing the wrong. The greatest improvement, however, was obtained by the deliberate selection of life situations, which afford opportunity to perceive and do the trustworthy act, along with verbal explanations and formulations such as slogans and mottoes which became meaningful by penetrating the experience and in turn made the experience more intelligible and fruitful.

But ideas become effective ideals only when they have led promptly to action that is accompanied or followed by satisfying effects. When this occurs frequently, the idea becomes an impulse to action; the individual is ready to act, and, as elsewhere, for him then to act is satisfying, for him not to act or to act differently is annoying.

QUESTIONS AND EXERCISES

1. Close your eyes and have some one put on the palm of your hand objects of various shapes. Study the first guess and the mental activities which follow in your effort to perceive the object correctly. Is the first guess a percept even when it is incorrect?

2. How would the Law of Parsimony, mentioned in Chapter I, influence our choice of explanations of "intuition"? Just how does the text explain intuition?

3. When you next experience some feeling or idea for which you cannot at once account, see if you can discover a simple explanation of the occurrence. Reread pages 219 ff.

4. Hold a small ink bottle a foot in front of your face, with the small end pointed toward your nose. Alternately close one eye and then the other. Draw pictures of the different views obtained. Do the views become more or less alike when the bottle is moved farther from the face? Were you ever conscious of these facts before? In what ways have they probably been previously utilized?

5. Trace the development of your ideas of your college from the time of your arrival. Illustrate trial and error, analysis, and combination.

6. Trace the development of your own ideas of *perception* or of *psychology* during this course. In what respects has it broadened and in what respects has it become more definite?

7. Illustrate and diagram an efficient method of teaching a child the idea of "warm."

8. Give samples from life of learning to respond correctly to abstractions such as "loyalty" or "honesty."

9. Give as many samples of an element with an opposite or unlike element as you can.

10. Give examples of failures of complete analysis due to (a) not varying the gross totals sufficiently; (b) having an insufficient number of gross totals; (c) failure to direct attention carefully to the element; (d) too many irrelevant details in the gross totals; (e) insufficient drill.

11. Select 10 sentences to assist in teaching the meaning of "active" and "passive" voice.

12. Make up several sentences varying the concomitants of "over" and so chosen as to direct attention to the meaning.

13. Make up sentences illustrating justice in which there is too much irrelevant detail.

14. How may definitions be successfully used to aid learning by analysis? What are the main requisites of a definition? Give good definitions of addition, weight, angle, subtract, hard, noun.

15. How is the Law of Effect related to the acquisition of ideals? How does an ideal differ from an idea? From mere habit?

16. Will the desired moral habits and attitudes be developed by imitation of adults? Just how will the activities of adults influence the child's learning? (Reread pages 271-280.)

17. What statements in the text would seem to favor self-government by school children?

REFERENCES

More extensive discussions of perception, especially of perception of space and time, will be found in W. B. Pillsbury, *Essentials of Psychology,* second edition, 1920, and Knight Dunlap, *Elements of Scientific Psychology,* 1922, chapter 13.

C. H. Judd, *Psychology,* second edition, 1917, chapter 10, con-

tains an interesting discussion of the relation of language and ideas.

For a discussion of the principles of analysis, see E. L. THORNDIKE, *Elements of Psychology,* second edition, 1912, chapter 14, or *Educational Psychology, Briefer Course,* 1914, chapter 12.

CHAPTER XIV

REASONING AND PROBLEM SOLVING

Reasoning is a form of learning. It is a term applied to types of learning that are at once very subtle and very complex. Reasoning may be contrasted with all types of activity mental or motor which consist merely in the repetition or recall of reactions previously acquired, or in mere random or aimless activity. Typically reasoning is involved when the individual is confronted by a novel situation or a problem-situation for which his native and acquired modes of reaction do not at once provide a satisfactory solution. The individual's final or consummatory action is delayed and during the delay he must *learn* what to do. The process of learning what to do by reasoning is not, however, to be sharply distinguished from ordinary forms of trial and error learning. The two merge but the extremes offer important contrasts.

The Characteristics of Reasoning

Some of the characteristics of reasoning may be observed by comparing the behavior of animals with those of men in problem-situations which embrace comparable features. When a cat is placed in a puzzle box that may be opened by some simple manipulation of buttons or latches, its activity seems to be mainly motor. It tries to squeeze between the bars, it claws or bites at buttons, wires, strings, and other objects loose and fastened. The

activity is usually incessant; there is very little evidence that the animal thinks the problem over—at least, it does not appear to "stop and think." It continues to try all of the forms of manipulation in its equipment, until finally the right move is hit upon, apparently by accident. When the cat is again placed in the box, it gives evidence of little understanding of the solution. It apparently does not know just how the previous escape was brought about. The task of learning the way out a second time is nearly as difficult as before. The solution is gradually acquired by a process of trials, elimination of annoying errors, and the selection of the successful, and hence satisfying, reactions.

The duplication of such an experiment with human subjects may be approximated by using a latch or some sort of mechanical puzzle which will be as new to the man as the puzzle box latch was to the cat. The general features of the learning by man are often very similar to those employed by the animal. The former resorts at once to manipulation, turning the parts this way and that, twisting, pulling, pushing; sometimes repeating the same futile effort time after time—foolishly, one who knew the trick might say—sometimes shifting rapidly without apparent aim, sometimes retracing the old steps. In the course of these varied attempts, the solution may be hit upon, often so unexpectedly that it is not understood at all. The second trial may then be much like the first; but at length the useless moves are eliminated, while those constituting the solution are retained and perfected. This we would be inclined to call a rather stupid human performance, in which little, if any, reasoning is involved. It is, nevertheless, a type of human learning that is not unusual when the problem is both novel and difficult.

Some learners, however, proceed in a different fashion.

They manipulate less while observing and thinking more. Holding the puzzle before them, they carefully study its construction, comparing the sizes of different rings and hooks, estimating the results of various moves, and keeping on the lookout for clues or suggestions. They may also attempt to recall the solutions of other puzzles, or to apply general or particular facts learned from preceding experiences with door locks, and other mechanical devices. The learner does more than merely manipulate the object; he recalls various facts which careful perception of the puzzle suggest, and manipulates or explores among these ideas. There is an active search to link the present problem up with past experiences which utilize the same principle. And this tendency to utilize recalled facts in addition to those that may be directly perceived in the problem-situation is one of the important characteristics of reasoning.

In reasoning, we have not sidetracked the familiar trial-and-error procedure. We have merely widened the field of manipulation. Not only may we explore among facts presented to the senses, but we may also explore among facts recalled. New facts may be observed not only in the situations present to the sense but in those present to mind. The recall of pertinent facts, general and particular, is an effective way of bringing our past experiences to bear upon our present difficulties.

The good reasoner not only recalls, but he carefully observes the present situation and his own reactions. The facts observed may be later recalled, so that he can rehearse the whole problem mentally, thus saving muscular work and often leading to a solution. Careful observation, too, often enables him to recall the state of affairs which attends an accidental discovery of the solution, thus avoiding the common waste of effort shown by ani-

mals that hit upon the solution without having perceived it. The careful observer may recall the circumstances and his own reaction and thus "see" how it happened, or, at least, observe clues whose usefulness appears during the next trial.

In reasoning, then, the first condition is a novel or problem-situation to which previously acquired or native reactions are an unsatisfactory solution. There is always a delay during which the satisfactory response is discovered. In working out the solution, the trial-and-error form of procedure is apparent. In this respect, reasoning is identical with other forms of complex learning. The distinguishing characteristics of reasoning embrace (1) an attentive, active analysis of the problem-situation by means of observation—not only visual observation, exploration, and analysis, but similar study through other senses such as hearing, as when one shakes a box to get an inkling of its contents, or smelling, tasting, feeling with the fingers, lifting, turning about, and variously manipulating—and (2) a conscious recall of past experiences, the utilization of ideas, general and particular, which recur during the study.

Insights and Hypotheses.—The result of observing many details and recalling many past experiences is the possibility of reacting to many selected situations operating at once. Solutions are discovered and new ideas or hypotheses conceived by getting together in a single moment of consciousness many aspects of the present situation and of past situations more or less relevant. Sudden insights into the problem, suddenly "getting a point," seeing into or "seeing through," suddenly conceiving a solution—these are other ways in which the culmination of reasoning is described. Perhaps the best general term with which to express the outcome of reasoning is *hy-*

pothesis, inasmuch as the "idea" conceived is not always a real solution. It is a possible solution sometimes proving to be correct, sometimes incorrect. In the latter case, the search continues until other insights or hypotheses are achieved. The solution is an hypothesis which proves satisfactory. In difficult problems, the correct hypothesis may be preceded by many incorrect ones which are eliminated in the process of further study.

An hypothesis is really a conscious response made to several features of the problem-situation and recalled ideas acting at once. "Seeing" many things at once, some fact contained in them or suggested by them comes to mind. Such hypotheses and discoveries during the process of thought are much like the perception of the roundness, equality, or other common aspects of several things observed at once. Indeed, they are a kind of perception, except that they may occur when the facts are not present to the sense but are only thought of, or when perceived and recalled facts are combined. Many discoveries are made during reasoning mainly because so many facts, apparently remote and unrelated, may be brought together in thought that could not be brought together as things or events in the actual world. Human ability to *represent* facts previously experienced thus broadens greatly the opportunity to learn.

How one "sees" facts in a collection of stimuli or particulars may be roughly illustrated by study of the "figures" which appear in the shifting glasses of a kaleidoscope or in a group of clouds or stars. In the collection of dots shown below, a number of different patterns or relations will be observed. The ink blots may also give rise to various percepts. These are curious reactions and easy to obtain, but they illustrate the character of insights which occur in the process of reasoning. Given a

complex group of items together, certain manipulations—that is, maneuvers which lead to a certain point of view—sometimes result in the sudden realization of a fact not previously noticed. Whether this result is called a percept, hypothesis, inference, deduction, insight, or discovery matters little. The suddenness with which it appears, though a long period of exploration may have preceded it, is frequently characteristic. It seems virtually to "pop out." Great discoveries are often finally "seen" with equal suddenness. "Hauy drops a bit of crys-

FIGURE 37. The dot and ink blot figures. Look at the dot figure, noting the several patterns which appear. Examine the ink blot to note how many different things may be seen in it.

tallized calcium spar, and, looking at one of the broken prisms, cries out, 'All is found!' and immediately verifies his quick intuition in regard to the nature of crystallization."[1] The world is full of facts awaiting some one sagacious enough to see them. The one who perceives them first makes a discovery and is accredited with genius. Others see them readily enough when they know what to look for and how to look. This point is well illustrated by a story from the life of Darwin, in which he describes his observations of some natural phenomenon after Agassiz's discovery of evidence of a glacial period in prehistoric days. "We spent many hours in Cwm Idwal, examining all the rocks with supreme care, as

[1] RIBOT, *Essay on the Creative Imagination,* p. 247.

Sedgwick (another eminent scientist) was anxious to find fossils in them; but neither of us saw a trace of the wonderful glacial phenomena all about us; we did not notice the plainly scarred rocks, the perched boulders. . . . Yet the phenomena are so conspicuous that . . . a house burnt down by fire did not tell its story more plainly than did this valley." [1]

The Solution of Verbal Problems

In any situation, reasoning comprises the analysis of the gross total facts into their constituents, the supplementation of these minute facts with others recalled from past experience, and the perception of previously unobserved facts in the new combinations of details. These characteristics may be illustrated by the solution of verbal problems of the type encountered in one form or another in everyday life, taking first a relatively simple problem which may be solved by an average child of seven and a half years.

Kate is cleverer than May.
May is cleverer than Jane.
Who is cleverest—Jane, Kate, or May?

The pupil must first grasp the problem or question, namely, "who is cleverest?" To succeed, this question must be held in mind during the exploration among the other facts. Next, the relevant facts concerning each individual must be perceived. To understand that "Kate is cleverer than May" requires some analysis in itself. One must observe not merely that there are two individuals, but the way in which they are related. Next, the relation of May to Jane must be similarly comprehended. But to perceive singly that Kate is cleverer than May

[1] *Life and Letters of Charles Darwin,* quoted from Sellars.

and that May is cleverer than Kate would be insufficient. These two facts must be seen together in the light of the question "who is cleverest?", before the solution is apparent. Success may not be achieved because the subject fails to understand the problem, because he fails to grasp the pertinent facts individually, because he fails to combine them properly or because, when properly combined, the relations are not observed.

The next problem is somewhat more complex. It is too difficult for an average seven- or eight-year-old child but may be solved by an average child of nine. It is a closer approach to the problems of everyday life, inasmuch as the facts essential to the solution are mixed with others that are quite irrelevant, thus making the task of analysis more difficult.

In cold, damp climates, root crops, like potatoes and turnips grow best;
In temperate climates, there are abundant pastures, and oats and barley flourish:
In sub-tropical climates, wheat, olives, and vines flourish:
In tropical climates, date-palms and rice flourish:
The ancient Greeks lived largely on bread, with oil for butter: they had wine to drink and raisins for fruit.
Which climate do you think they had?

To solve this problem, the child must first fix upon the main question, which requires some analysis. Out of the last two statements the "What climate did they have" statement must be combined with the notion of Greeks, so that the question becomes clearly "What climate did the *Greeks* have?" The solution will not be obtained unless this question is perceived and remembered. Next, information not contained in the problem-situation must be available and it must be suggested by getting the right facts together. The child must know that *bread* comes from wheat, and not from root crops, potatoes,

turnips, date-palms, etc. He must know also that oil comes from olives rather than oats, potatoes, rice, etc., and that raisins are to be associated with vines, rather than with date-palms, turnips, etc. These facts, assuming that they are known, must be brought out during a process of study in which many irrelevant matters are observed and discarded. Several erroneous hypotheses may be suggested as various facts are viewed together before the correct solution is obtained by narrowing the field down to the facts contained in lines 3, 5, and 6, and seeing the relations contained therein.

In the reasoning of the adult, or even of the genius, we do not move into a new mental realm or encounter abilities utterly different from those found in the efforts of the nine-year-old child, but merely ascend to higher levels on the same scales of abilities. As the problems mastered by the twelve-year-old child would surpass the comprehension of the younger children, so the operations of the genius in his field are perplexing to the ordinary adult. But in making the most profound discoveries, the man of genius excels the average man only in utilizing at once more facts, which he sees more clearly and in greater detail, among which he selects and rejects in more subtle fashion, and in which he perceives relations more sagaciously.

Types of Reasoning

The mental operations which comprise reasoning are essentially the same in the many varieties of problems that are encountered. Any situation which is at once novel and complex, whether in practical affairs, school subjects, religion, aesthetics, music, or any other field, provides the occasion for reasoning. In addition to the problem-situation, there must be a motive. And the

variety of motives is wide. We may reason just for the satisfaction in mastering a problem, although more frequently the incentive is the desire to secure some end—food, comfort, a fact needed in business—or to avoid some annoyance, such as confinement, deprivation, or thwarting. No convenient categories seem to include all varieties of motives nor of problem-situations, but the following groups suggest types that are distinctive with respect to the general methods of procedure.

1. **Finding the Key to a Complex Situation.**—Most of the practical problems fall under this head. Typically, the individual is confronted by a complex situation, which offers a large number of possible reactions. The question is to find the one satisfactory response, that is, the solution, as when we encounter situations and ask such questions as "What is this?" or "What is this for?" "How is it used?" "What does this mean?" "Where can my umbrella be?" "How did this get here?" or "How did you do that trick?" In all of these cases the number of interpretations is legion. We must take them up one after another, try them out, reject useless clues, follow up promising lines, supplement them by recalling past experiences and trust to eventually getting together the combination of details which will suggest the answer to our question. The solution of mechanical puzzles, the search for the cause of the balking of an automobile, for the main point in a poem are of the same type. The essential characteristic of this type of reasoning is the presence of a large number of facts or details, out of which we must find a satisfactory response.

In the foregoing illustrations the solution was typically some concrete line of action or the perception of some particular fact which was the key to the situation. The so-called *inductive reasoning* so abundantly utilized in

science is essentially the same, except that the key is typically a general rather than a particular fact. Science aims to discover laws, or general explanations. Thus Darwin, after observing a large number of variations among animals of the same species, and similarities among different species which amounted to an essential continuity, finally conceived a single explanation for all of these facts, namely, the *theory of evolution.* This theory was really a key to the complex situations, in much the same sense that after puzzling for a time with an arithmetic problem, a child sees that the thing to do is first to add certain figures, and then subtract another figure from the sum. As a psychological process it makes little difference whether the solution is a great law, or a particular fact.

2. **Application and Verification.**—Reasoning may take its start from a general principle and seek for particular cases which illustrate it. One may attempt to *apply* a general law, either for the purpose of observing whether it holds good or not or for the purpose of understanding it better by practice in using it. If one's interest is in testing the validity of a general statement, the process is called *verification.* If one does not question the generalization but wishes to find new particulars which it covers, the term *application* is commonly used. In either case the general fact becomes one element in the situation which must be grasped and held in mind, while various concrete situations, perceived or thought of, are viewed with it. Getting the general and particular facts together, one must perceive their essential similarities or differences; one must see whether they fit or are unrelated. Of course, there must be a great deal of exploration, trial-and-error activity, in recalling particular cases and trying them out. This form of thinking,

of which there are several varieties, is called *deductive reasoning* in contrast to the *inductive* method, but both are essentially the same psychologically. Both imply a novel and complex situation, a search for clues, the recall of facts and experiences, and the thinking of several things at once.

In many instances, both the inductive and deductive procedures are employed. In trying to figure out the use of a new piece of apparatus, one may be led from the study of particular parts to an hypothesis concerning the whole and then attempt to verify the hypothesis by applying it to the concrete situations which the theory suggests. In scientific investigations a general law, such as the Law of Effect, which is arrived at after long study of particular events, is later tested by trying it out in new situations in which it should hold, and is finally applied broadly to meet practical needs. On a smaller scale, laboratory experiments may involve the same steps: discovery of the "key" or general law, verification and proof, and application.

The Improvement of Methods of Reasoning

With the characteristics of reasoning now before us, we may undertake a discussion of the equipment essential to good reasoning, the methods by which and the extent to which reasoning may be improved.

The Need of Facts.—Successful reasoning depends upon an abundance of ideas, particular and general facts and principles. In reasoning, we pick and choose among facts; view this and that together. Few people are able to reason about the Theory of Relativity, Evolution, or Electro-therapy because of a lack of the essential stock of facts. And some who could reason well concern-

ing the explanation, application, or verification of these theories, might reason very poorly about a balking automobile, investment securities, or pains in the chest, because of lack of information concerning mechanics, finance, or the diagnosis of disease. Unless the person has had previous experience with a situation in some degree similar, unless he has dealt with material of the same sort before, he may be quite incapable of finding a solution except by accident. An eminent thinker once compared the situation during reasoning to two chambers, a main chamber in which manipulation and study were going on, or in which the leading ideas were being rehearsed, and an antechamber crowded with ideas seeking an entrance to the main room. Unless the antechamber were well filled, little could be done. The most hopeful sign of probable success was an anteroom teeming with candidates for a "trial." If we are to become competent thinkers in any line, the first, and by all odds the most important, thing is to accumulate experience and master the facts in that field. Without the facts and experience, the most gifted mind would be helpless. The most productive thinkers are not those who disregard the knowledge, methods, trials, and errors of others, but those who are most familiar with them. Originality is not opposed to the amassing of facts or the laws of ordinary learning, but dependent upon them.

In a genuine sense, one's reasoning ability in a particular field is increased by an enlargement of knowledge and experience, but this is not the same as saying that some *general power* has been improved. We may not have improved our machinery; we may have merely accumulated raw products with which to increase the output. Facts, as we tried to show in the preceding chapters, may be acquired, in useful or clumsy form, so

that other things being equal, the person who learns in the best way will be more successful in reasoning. To learn how to learn, and to learn a great deal, are probably the two most important aids to efficient reasoning.

Mere accumulation of scattered information and experience is in itself an insufficient guarantee of ability to reason usefully. Minds which accumulate facts after the fashion of the newspaper "factogram" column or the encyclopedia of knowledge about everything are seldom competent thinkers. A Jack-of-all-trades is a master of none. Our ability to solve problems in arithmetic depends upon mastery of arithmetical facts, in history upon historical facts, and in every other line upon knowledge or experience in *that* line. For each new problem that we face, reasoning is a process of review and reorganization. Much depends on what is present, and how it is present, in order that it may be reviewed and rearranged. It is therefore not surprising to find that individuals capable of productive and valid reasoning along one line are conspicuously lacking in sagacity along others. At the most, we can display originality in but few fields; reasoning ability is usually specialized in accordance with our experience and training.

The Need of Practice Under Guidance.—Given an abundance of information, the task of improving the ability to solve problems is much like the task of improving other abilities such as reading, spelling, writing, or the use of oral English. First of all, there must be an abundance of practice. We learn to think by thinking. But just as in typewriting a learner left to himself is likely to improve slowly, to develop many ineffective devices, and to fail to acquire many elements of effective technique, so in reasoning best results are obtained by practice under guidance. The teacher may assist

appreciably by suggesting good practices and detecting several rather common forms of ineffective technique.

Keeping the Problem in Mind.—The first step in the process of solving a problem is to understand thoroughly and remember the main question.

In a test which has been widely applied to children of various ages, two small boxes weighing three and fifteen grams respectively are presented, with these instructions: "You see these blocks. They look just alike, but one of them is heavy and one is light. Try them and tell me which one is heavier (or heaviest)." In some cases, five-year-old children fail in this test when they understand the directions and are able to discriminate easily between the weights, because they forget what the problem is. The task furnished by the instructions "Try and see which is heavier," must be held firmly enough in mind to control the steps necessary for making the comparison. Such distracting impulses as to feel the blocks, pile one on the other, roll them about, etc., must be inhibited. One must move straight toward the goal. Terman, who has studied this test, finds that sometimes a very dull child starts off in a most promising way but soon appears to have forgotten the task. "His mental processes are not consecutive, stable, or controlled. He is blown about at the mercy of every gust of momentary interest."

The problem held clearly in mind acts as a selective agency during the activities of reasoning. It tends to favor the perception of the facts appropriate to the solution of the problem. If some one speaks a sentence of which we hear only the final word *scale,* there are several ideas which may occur: a fish scale, weighing scale, music scale, scale of prices, a writing scale, "scale" a fence. But when the context of the sentence is known,

the relevant meaning, and it alone, comes to mind. The successful thinker finds that out of the variety of possible meanings which each detail may yield, only the right one pops out. Others find that the right suggestion will not come. Tell a subtle joke to any group; some will see the point at once, but to others it comes slowly or not at all. When the right idea does not come, one is not left altogether helpless. One should not passively wait for something to come. Success may be achieved by instigating certain maneuvers.

A Systematic Analysis of Details.—The first maneuver is to proceed with the main question in mind and to examine actively the problem in piecemeal. Focus attention on one detail. Significant matters overlooked when the problem is thought of as a whole may be detected during an active study of one phase after another. In teaching, the habit of analytic scrutiny may be encouraged by questions directed to parts of the problem. Systematic precedure, in which details are taken up in orderly fashion, their relation to the problem ascertained and futile leads noted, should be cultivated by means of practice under guidance.

One trait, antagonistic to successful reasoning, is inflexibility. In attempting to solve a mechanical puzzle, a subject observed by Ruger spent ten hours on one line of attack. After having stated his assumption, which was an erroneous one, the subject was requested to strike out along other lines. After an hour and a quarter, he was asked again to tell what he was doing. He was still working on the same futile clue! This kind of stubbornness or inflexibility is a fatal obstruction in the pathway of reason, and is reminiscent of the logic-tight compartments mentioned in Chapter IX. It amounts to sticking in a rut, closing the mind to new suggestions,

and results in disregarding very obvious clues. In dealing with many practical situations as well as political, social, and business issues, the same tendency appears as a disinclination to change a point of view, or even to reconsider an old problem. To attempt to change an opinion, to venture a new solution of a problem, is usually somewhat disturbing and perplexing in much the same way as an attempt to speed up in reading or adding or to adopt a new method of typewriting. The ease and security which results from standing by old habits of thought and action oppose the tendencies to break away, to develop and try out new possibilities. Extreme conservatism, stubbornness, and inflexibility, then, are habits that the good thinker must avoid. Originality depends, in some degree, upon habits of open-mindedness, of keeping alive to wide variety of stimuli, and of remaining sensitive to all of the suggestions that a situation may contain, rather than in thinking only along the line most readily suggested.

Some subjects show a tendency to skip about among the details of a problem in a superficial fashion, which is quite as serious a fault as too great a tenacity in sticking to a few clues. A promising line is undertaken and followed up for a while, only to be suddenly dropped as another suggestion occurs. This kind of learner is too readily distracted; he is continually getting very "warm," but by hastiness is robbed of a victory fairly within his grasp. In solving problems in arithmetic, history, and civics, and in practical affairs, habits of careless superficial thought may betray themselves in impulsiveness. The child leaps to conclusions with little effort to test the results. This is, indeed, a quite common form of human fallibility. There seems to be a native disposition to accept as reliable any idea that

comes easily. While guessing is to be encouraged and while it is in general healthy to entertain suggestions that thinking produces, it is quite as desirable to establish habits of maintaining a state of doubt, of being critical, and of testing suggestions before they are accepted. Both "scatter-brain" thinking and inflexibility may to some extent be remedied by cultivating the habit of systematic procedure coupled with efforts to formulate articulate hypothesis, or possible forms of solution. After a preliminary survey, the subject should fix upon what appears to be the most pertinent facts and, considering them in connection with the problem, formulate a clear-cut guess or hypothesis concerning the solution. Teachers may assist by asking the pupil, "What is your problem?" "What facts are you now considering?" "What do you think is a possible solution?" The learner should work, not aimlessly waiting for things to happen, but with a definite question or assumption in mind. Each assumption should be tested until its worth is determined beyond a reasonable doubt, then dropped and another taken up, until one by one the possibilities are exhausted. Such a procedure tends, for one thing, to narrow the field of operations. If the solution does not show itself spontaneously, it may be finally cornered and thus captured. Changes in the assumptions widen the possibilities for suggestions, since the same details may be perceived differently as words may have different meanings, when the point of view is changed. Solutions coming as the answer to the question, or in the course of the testing of a hypothesis, are better understood than those which "just come." If the solution is anticipated, and linked with an assumption, it is better observed and understood. Usually an assumption grows out of past experience which is formulated as a general rule or prin-

ciple. The present solution is then perceived as a case which fits into a familiar type.

Generalization.—The subject, then, should study details in connection with the main problem, attempt to guess the solution as he goes along, give each guess a fair try out, and advance systematically. When the problem is solved, it is advisable frequently to review some of the steps in an effort to generalize, or get the principle of the problem. The value of generalization was shown very clearly in the studies of mechanical puzzles, as indicated in the following quotation from Ruger: "A certain puzzle was so arranged that it could be presented in various forms. The manipulation for these various forms could all be comprised under a single formula. This general formula could be deduced from any one of these special forms. A number of subjects were tried with the puzzle. As soon as skill was acquired in dealing with one form of the puzzle it was changed to another form. The subjects who developed the general formula during the solution of the first form were able to use in the second form the specialized habits built up in the first form. Those who formed merely the special habits without developing the principle attempted to carry over the habits without modification and were greatly embarrassed by the change."

The value of the generalization is quite as great in the individual acts of problem solution as in the wider investigations of science. The development of general principles is, as we observed in Chapter I, the outstanding aim of science. The usefulness of general principles lies in the effectiveness with which they may be applied and thus explain individual problems. The subject who extracted from the complexity of the mechanical puzzle the general rule, succeeded in applying it to other

situations, thus achieving the solution at once. The good thinker not only solves his problem but explains the solution. He seeks an understanding of this particular experience in the light of others, especially in the light of some general rule or formula, as illustrated in an incident recorded by James:

"I am sitting in a railroad-car, waiting for the train to start. It is winter, and the stove fills the car with pungent smoke. The brakeman enters, and my neighbor asks him to 'stop that stove smoking.' He replies that it will stop entirely as soon as the car begins to move. 'Why so?' asks the passenger. 'It always does,' replies the brakeman. It is evident that the connection between the car moving and smoke stopping was a purely empirical one in the brakeman's mind, bred of habit. But if the passenger had been an acute reasoner, he, with no experience of what that stove always did, might have anticipated the brakeman's reply, and spared his own question. Had he singled out of all the numerous points involved in a stove's not smoking the one special point of smoke pouring freely out of the stove-pipe's mouth, he would, probably, owing to the few associations of that idea, have been immediately reminded of the law that a fluid passes more rapidly out of a pipe's mouth if another fluid be at the same time streaming over that mouth; and then the rapid draught of air over the stove-pipe's mouth, which is one of the points involved in the car's motion, would immediately have occurred to him."

Verification of Results.—In the scientific method, generalization is closely related to verification. The general hypothesis is not accepted uncritically but put to the most rigid test. It is verified by retracing all of the steps by which it was achieved, by application to new situations which seem logically to be covered by it, and by searching for instances which are contradictory. Whether

application and criticism is wholly mental or carried out in the form of miniature tests and experiments, the outcome to be sought is a habit of self-criticism, or reasonable doubt, of impersonal verification.

Habits of testing an obtained solution are of threefold value. They assist pupils to analyse their own difficulties, to detect their own errors, and to understand the conditions under which thought goes astray. They assist the pupil to maintain a standard of accuracy for himself. They lead to a more impersonal attitude toward thinking, to a tendency to adopt the scientific attitude of distinguishing evidence from prejudice and logic from fancy.

The Study of Scientific Methods.—The methods of science, as we observed briefly in Chapter I, are little more than an outline of an ideal form of reasoning. Indeed, the methods of science were devised precisely because individual thinkers and thinking are often prejudiced, untrustworthy, and superficial. As the man of science must surround himself at every step with cautions and checks in order to arrive at the correct conclusion, so the thinker in ordinary matters should exercise similar precautions. "Scientific thinking" is merely careful, critical, safeguarded, systematic thinking. Detailed descriptions of the procedures by which men of science have solved their problems and achieved discoveries, as well as the rules by which their thinking is governed, constitute models worthy of emulation.

The Study of Logic.—Logic is the study of the outlines of representative forms of reasoning. Logic is not much concerned with the processes of reasoning, that is, the difficulties of keeping the problem in mind, the futile moves, etc. It is concerned with the validity of the results reached—whether the solution is justified or

not. Logic is related to reasoning in somewhat the same way that grammar is related to composition. The study of grammar will do little to develop skill or style in writing, but it will assist in the task of detecting correct and incorrect usages and enable the learner to repeat the former and avoid the latter. Similarly, logic may assist in indicating forms of thought that are valid and invalid.

In logic, samples of reasoning are analysed into their elements, which are usually displayed in a simple graph, diagram, or short series of sentences. These summaries make more apparent various fallacies that were obscure when expressed in cumbersome or expansive verbal form. The various correct and incorrect forms of reasoning may also be classified in several types. Once an effective classification is made, reference and interpretation may be facilitated.

Properly utilized, knowledge of logic—especially of the common fallacies in thought—may be of some value in developing more valid and rigorous habits. But like rules in grammar, rules of logic may be learned quite independently of the activities they are supposed to assist. One may fail to understand the rules adequately, or may forget them, or fail to utilize them, or be unable to utilize them. Like other verbal formulations they must be introduced during concrete experiences. They must be illustrated by and fused with the activities of reasoning.

Supervised Problem Solving as a Group Activity.—The returns for time spent in introducing the facts of logic, scientific methods, illustrations of how eminent people solve their problems, and other verbal instructions concerning reasoning will at the best be quantitatively small. The slender improvement thus secured

will, however, be eminently worth while. Greater advances will result from careful supervision, in which individual defects and deficiencies are discovered and sagaciously remedied, and in which good habits are recognized and rewarded.

To utilize recitation periods not for the purpose of conducting inquisitions but to stimulate, exercise, and improve habits of thinking is one of the most productive of modern methods. The social group provides not only a situation which brings out certain idiosyncrasies such as timidity, extreme caution, hastiness, pugnacity, stubbornness, and tendencies to rationalization or self-justification, but it provides the most effective weapon —group opinion bluntly or subtly expressed—with which to remedy the difficulties found. It is in group activity that both the "problem attitude"—that is, the tendency to question reasonably, criticise, evaluate, explain rather than merely accept — and the "scientific attitude"—that is, the tendency to think cautiously, thoroughly, systematically and impersonally rather than carelessly or with prejudice—may be most adequately developed.

Difficulty vs. Success.—The difficulty of problems should be carefully adjusted to the capacity of the pupil. Problems on the one hand may be too easy to enlist the child's best and livest interests and abilities; on the other hand, they may be too difficult, inviting the chagrin of failure. There is little interest in the attempt to lift a 500-pound weight which means failure, or in continuously twiddling one's thumbs, which is monotonously easy. Activities that exercise one's maximum abilities, physical or mental, are most useful and interesting.

Of the two defects in the choice of reasoning problems,

the most common is the selection of materials and situations that are too difficult. Inventories of achievement in problems in arithmetic, geography, civics, and other school subjects show too large a percentage of failures. In part, this fact has been due to the belief that mere difficulty—hard issues, or challenges—are the most effective incentives to reason. It has been believed that the "problem attitude" is stimulated by great difficulties, that children enjoy meeting the challenge which a hard task presents. What children really like is not insurmountable difficulty but the mastery of a real problem. They are not so much interested in merely facing a difficulty as in successfully overcoming a difficulty. Successful achievement, getting things done, feeling one's power—not annoying lacks and perplexing failures—these are the incentives to further accomplishment.

"As between difficulty and success, success is in the long run more productive of thinking. Necessity is not the mother of invention. Knowledge of previous inventions is the mother; original ability is the father. The solutions of previous problems are more potent in producing both new problems and their solutions than is the mere awareness of problems and desire to have them solved." . . . "Not getting answers seems as a rule to make us stop trying to get them. The annoying lack of success with a theoretical problem most often makes us desert it for problems to whose solution the existing bonds promise to be more adequate." [1]

Adjustment to Age and Individual Differences.—Series of reasoning problems, graded according to difficulty, may be usefully employed to ascertain the level which the reasoning abilities of children have attained at various ages. Such problems may be utilized as a

[1] E. L. Thorndike, *The Psychology of Arithmetic*, p. 278f.

scale with which classroom materials may be compared. They may also be employed to evaluate individual abilities, to discover inappropriate methods of reasoning, and to encourage better technique.

A Series of Graded Reasoning Tests

Each of the following is selected from a set of five for each age. The problems are of such difficulty that approximately one-half of the children of a given age will succeed and one-half will fail.

7 Years

All wall-flowers have four petals: this flower has three petals. Is this a wall-flower?

8 Years

All great men work hard and long every day: Sir John Smith worked three hours a day. Was Sir John Smith a great man?

9 Years

Three boys are sitting in a row: Harry is to the left of Willie: George is to the left of Harry. Which boy is in the middle?

10 Years

There are four roads here. I have come from the south and want to go to Melton. The road to the right leads somewhere else: straight ahead it leads only to a farm. In which direction is Melton—north, south, east, or west?

11 Years

Where the climate is hot, aloes and rubber will grow: heather and grass will only grow where it is cold. Heather and rubber require plenty of moisture: grass and aloes will grow only in fairly dry regions. Near the river Amazon it is very hot and very damp. Which of the above grows there?

12 Years

Field-mice devour the honey stored by the bumble-bees: the honey which they store is the chief food of the bumble-bees. Near towns there are far more cats than in the open country. Cats

kill all kinds of mice. Where, then, do you think there are most bumble-bees—near towns, or in the open country?

13 Years

A pound of meat should roast for half an hour: two pounds of meat should roast for three-quarters of an hour; three pounds of meat should roast for one hour: eight pounds of meat should roast for two hours and a quarter: nine pounds of meat should roast for two hours and a half. From this can you discover a simple rule by which you can tell from the weight of a joint how long it should roast?

14 Years

John said: "I heard my bedroom clock strike yesterday, ten minutes before the first gun was fired. I did not count the strokes but I am sure it struck more than once, and I think it struck an odd number." John was out all the morning, and his clock stopped at five to five the same afternoon. When do you think the first gun was fired?

QUESTIONS AND EXERCISES

1. Solve the problems given at the end of the chapter (above) and in the case of those which offer difficulty, attempt to describe the mental operations involved.

2. Typewrite the problems and try them on children of different ages. See if you can ascertain the good and the bad features of their methods of reasoning.

3. Do you think such a list of problems really provides a measure for general ability to reason? For which of the following fields of reasoning would it probably be the best test—law, medicine, mechanics, business, music, science, history, art, philosophy, economics? For which the poorest?

4. Do you think that training in logic or scientific methods would increase efficiency in solving such problems? Would training in arithmetic? Grammar? Geometry? Algebra?

5. If you were to extend this list to make a better test of ability to reason, what kinds of *content* would you prefer?

6. Buy a few mechanical puzzles from some toy store. Carefully examine your procedure during solution. See if you can apply any of the suggestions given in the chapter. Try the same puzzles on friends, both children and adults. Record the time required to solve the puzzle. Put the puzzle together and have

them try it again and repeat until they reach a physiological limit. Compare the methods of children and adults with references to care in observation, the search for general principles, the recall of previous experiences, the formation and use of hypothesis, the understanding of the solution, etc.

7. See what you can do by way of explanation and illustration to improve the methods of attack used by others.

8. Do animals reason? Before giving your final opinion, read over the sub-headings of Chapter I.

9. What facts presented in Chapters I and IX bear upon the study of reasoning? What other chapters have a bearing on the psychology of reasoning?

10. Does the average farmer, chauffeur, stenographer, salesman, cobbler, housewife, physician, or banker reason very much? After several years of experience in any of these vocations, is it more or less *necessary* to reason in order to get along efficiently than at the beginning? After several years is one more or less *able* to reason in that field?

11. How often do you reason when it is not necessary or "for the fun of it"? Just what *is* "the fun" of it? Has it an instinctive basis? Do you get much enjoyment out of puzzles that are so difficult that you nearly always fail?

12. State your opinion on these assertions: (a) We require in general too much learning by rote in our schools; (b) If we clutter the child's mind with memorized facts we interfere with his thinking; (c) It is not that too much is memorized, but rather too little; (d) It is not that too much is memorized, but that unessential material is learned; (e) Not too much memorization, but memorization in ineffective ways.

13. Would it be worth while to study the methods that great men think they employ in reasoning? What are some of the limitations of this method of improving reasoning ability?

14. Of the various suggestions offered for the improvement of reasoning, which do you consider most important? Which least important? Why?

15. Would it be worth while for you to study the defects or deficiencies in your own methods of thinking? What are the difficulties?

16. While solving the following riddles, see if you can detect inappropriate methods in your own work:

a. "Use me well and I am everybody. Scratch my back and I am nobody." What is it?

b. What is full of holes and yet will hold water?

c. The man who made it wanted to sell it. The man who bought it never used it. The man who used it never saw it. What is it?

17. Which is more likely to cause a high school boy to think,—the study of formal logic or a serial detective story? Will either improve ability to reason in general? What material would be better than either?

18. One writer describes reasoning as "selective thinking." What does this phrase mean? Is it a satisfactory definition of reasoning?

REFERENCES

JOHN DEWEY, *How We Think,* 1910.

W. B. PILLSBURY, *The Psychology of Reasoning,* 1910.

H. A. RUGER, *The Psychology of Efficiency,* 1910.

F. G. BONSER, *The Reasoning Ability of Children of the Fourth, Fifth, and Sixth Grades,* 1910.

The graded reasoning tests, and others similar to them, will be found in CYRIL BURT, *Mental and Scholastic Tests,* 1921, p. 356 ff.

CHAPTER XV

THE TRANSFER OF TRAINING

In the preceding chapters we have considered mainly the amount, rate, and limits of improvement and the factors which contribute to making the amount great, the rate rapid, and the limits high. In this chapter, we shall consider the degree to which training in one function may contribute to ability in another. This will involve several problems which are practically, if not theoretically, distinct. Does learning to memorize poetry increase one's ability to memorize prose; or does learning to cancel all of the A's on a page improve one's ability to cancel B's? In these cases the forms of the functions are roughly identical and the data—words in one case, letters in the other—are similar. Next, does practice in memorizing prose transfer to the ability to memorize telephone numbers, names and faces, or musical selections? Or does practice in cancelling A's contribute to one's ability to cancel digits, geometrical drawings, or other items? In these cases the functions are alike in form but the data are quite unlike. These questions might be consolidated into a single query, viz., Does practice in perceiving, memorizing, or reasoning with one type of subject matter improve that mental process in general? Can we improve memory, perception, imagination, reasoning in all fields by practice in one? If the answer to these queries is a positive one, it would be proper to ask a still broader question: Can

we improve the mind or intelligence in general by practice in memorizing non-sense syllables, perceiving small differences in colors, visualizing faces, solving problems in arithmetic, or by other forms of practice? Similar questions might be asked, such as: Can we improve initiative, originality, perseverance, reasonableness, love of truth, dependability, or—more broadly—character and personality by practice in a specific task? And if so, in what tasks, by what kind of practice, and to what extent? In considering these questions, we should not overlook the possibility of negative transfer. It is possible that too much practice in learning prose by rote may interfere with learning names and dates, or that this practice may have an inhibiting effect on fluent reading or on learning "by ideas," or that it may set up habits which impede independent thinking and reasoning.

The Old View of Transfer

The old view, held by specialists in education as well as by laymen generally, was that memory, judgment, discrimination, observation, reasoning, attention, will, etc., were general faculties or powers which operated indiscriminately in all lines or on all kinds of material. Individuals were said to have good or bad memories, judgment, or will; and it was implied that these traits were about equally good or bad in all situations. It was assumed that these faculties, powers, or processes could be trained as a unit. Indeed, it was the function of the school to develop memory, reason, judgment, and other such desirable traits. It was assumed, furthermore, that certain subjects, such as Greek, Latin, mathematics, and formal grammar were especially effective instruments for the training of the mind. In the textbooks of twenty-

five years ago such quotations as the following were frequent:

The value of studying German "lies in the scientific study of the language itself, in the consequent training of the reason, of the powers of observation, comparison, and synthesis; in short, in the upbuilding and strengthening of the scientific intellect."

"The pursuit of mathematics gives command of attention" and results in "the strengthening and training of the reasoning powers."

"Will-power and attention are educated by physical training. When developed by any special act, they are developed for all acts."

Such views are now considered extravagant—at least by those who have followed the experimental studies of the transfer of training. The older notions still have an appeal, however, as is shown by the popularity of the widely-advertised systems of training for memory, initiative, will, and other traits.

The Effects of Memory Training

For several decades, including the present one, systems of memory training especially have been extensively utilized. Most of these systems are based on the assumption that memory may in general be trained by a period of practice—fifteen minutes or thereabouts a day for a few weeks—with names, numbers, or other types of material.

In William James's *Principles of Psychology*, published in 1890, were given the results of the first experimental study conducted to ascertain whether training on one kind of material increases ability to memorize another kind of material. James memorized in the

course of eight days 158 lines of Victor Hugo's *Satyr*, a task which required 131.8 minutes. Then, for 38 days he spent 20 minutes per day in memorizing passages of Milton's *Paradise Lost*. Following this practice he again memorized 158 lines of the *Satyr*, finding that it required 151.5 minutes. Two weeks of practice on one kind of poetry had not improved his ability to memorize another kind of poetry. A similar experiment was subsequently tried by four of James's students, three of whom were slightly more efficient and one slightly less efficient in learning material somewhat different from that which had been practised. These experiments, while not conclusive, are of historical significance since they stimulated further experimental study by methods more refined.

Sleight, for example, divided a group of women students, ages 18 and 19, into four subgroups. Group 1, a "control" group received no special training; Group 2 learned from 30 to 60 lines of poetry daily (30 minutes a day for 12 days); Group 3 memorized tables, such as population data, export and import tables, and foreign coinage system 30 minutes a day for 12 days; Group 4 spent 30 minutes a day for 12 days attempting to learn the substance of scientific, historical, or narrative prose selections read to them. Just before and just after the practice series, the abilities of all four groups were measured in the following kinds of learning:

1. Learning series of names and dates given orally
2. Learning series of non-sense syllables given orally
3. Memorizing pieces of poetry, read by the experimenter and repeated by the subjects
4. Memorizing prose, as in (3) verbatim

5. Getting the substance of a prose selection presented orally
6. Memorizing a series of 9 letters read but once

By comparing the improvement of each of the *practice groups* in each function with that of the *control group,* the transfer of training was measured as shown in the accompanying table:

SUPERIORITY OF PRACTICE GROUPS 2, 3, AND 4 OVER CONTROL (UNPRACTISED) GROUP 1 IN IMPROVEMENT, GAINS, OR LOSSES (—)

GROUPS COMPARED	1. LEARNING TABLES	2. LEARNING NON-SENSE	3. LEARNING POETRY	4. LEARNING PROSE VERBATIM	5. PROSE SUB-STANCE	6. RECALL-ING LETTERS	AVERAGE OF ALL SIX
Superiority of Group 2 (poetry practised) to Group 1 (unpractised) in improvement in...	32	33	33	9	— 7	— 24	13
Superiority of Group 3 (tables practised) to Group 1 (unpractised) in improvement in...	59	9	— 27	— 36	49	— 3	8.5
Superiority of Group 3 (prose substance practised to Group 1 (unpractised) in improvement in...	— 6	— 62	— 7	— 17	52	27	— 2

Observe first that each group improved the most in learning the material that had been practised. Thus Group 2, which practised poetry, exceeds Group 1 (unpractised) in improvement in learning poetry by 33; Group 3, which practised learning tables, exceeds Group 1 by 59, and Group 3, which practised prose substance, exceeds Group 1 by 52 in that function.

The influence of training in one type of learning on other types is sometimes favorable, sometimes unfavorable. Practice in getting the substance of prose had a bad effect upon all other forms of memorizing save the "immediate" memory for a series of 9 digits. Practice in

memorizing poetry produces an improvement in learning poetry, tables, non-sense, and prose literally, but makes it harder to learn prose substance or recall letters. Those who practised learning tables were more able to learn tables, prose substance, and non-sense, but less able to learn poetry, prose verbatim, and recall letters. Transfer may be positive or it may be negative. Practice in one kind of learning may facilitate or it may inhibit other kinds of learning, within the same general field.

Other investigations of the effects of the training of memory for one kind of material have shown a transfer of improvement to memorizing other kinds of material that is seldom great, usually between five and fifteen per cent. Often it is less than five per cent and occasionally zero or negative.

The Effects of Training in Judgment and Perception

One of the earliest experiments on transfer in the field of observation and judgment was performed by Thorndike and Woodworth in 1903. They found that subjects who had practised estimating the areas of rectangles of certain sizes (10 to 100 square centimeters) until large improvement had been attained, showed only about a third as great improvement when slightly larger rectangles (150 to 300 sq. cm.) were given, or when the areas were kept constant but the shapes changed. These investigators also found that a period of training which brought about considerable improvement in judging the lengths of lines from one-half to one and one-half inches in length yielded no increase in ability to estimate lines from six to twelve inches long.

Thorndike and Woodworth found that individuals who by practice had markedly increased their ability to pick out words containing the letters e and s showed less than one-third as much improvement in marking words containing i and t, s and p, c and a, a and n, or l and o. Training in perceiving English verbs gave a reduction in time of 21 per cent, but when the same subjects were tested in perceiving other parts of speech they showed a reduction in time of but 3 per cent and an *increase* in omissions of more than 100 per cent. Another investigator, Kline, gave nine individuals practice in cancelling c's and t's from 30 to 45 minutes a day for 14 days. Before and after the practice, the subjects were tested in cancelling nouns, verbs, prepositions, pronouns, and adverbs. Eight other individuals, who served as a control group, were given the same initial and final tests, but received no practice in cancelling c's and t's. The practice group showed less improvement in cancelling nouns, verbs, etc., than the control group. Apparently, practice in cancelling letters may cause not an improvement but a decrease in ability to cancel words of certain types.

Conclusions from Studies of Memory and Perception.—In these experiments, the general form of the function was kept constant—that is, the subjects were trained to judge areas and lengths of lines, or to cancel items from the printed page—and the tests were devised to see how well the same subjects were able to make the same kind or *form* of response to data, areas, lines, or letters which differed slightly or greatly. The significant fact is that when data are used which are but slightly different from those on which practice was given—as when prose is substituted for poetry, or when *i* and *t* are substituted for *e* and *s,* or when long lines

are substituted for short—the improvement is relatively small. When the items are more unlike those used in training—as when names and dates are substituted for prose, or when verbs and nouns are to be cancelled instead of letters—the transfer is very small, often zero or negative.

One reason for these findings is that memory, observation, discrimination, and other processes are not such unitary and distinct processes as the use of such terms frequently implies. Memorizing, for example, far from being a constant process, may involve very diverse elements. According to the circumstances, one may memorize by merely repeating, mechanically, one item after another; by utilizing a number of artificial aids, such as positions in the series; or by searching for meaningful associations. Memorizing may, in fact, range from mechanical articulation of items to an intensive, analytical attack on the material, which really amounts to reasoning. The lines of demarcation between the several mental processes are not so obvious as they seem. Moreover, there are not, in memory or in other processes, convenient and stable units, like muscles in the arm, which yield themselves to general improvement as the result of exercise of whatever sort. These processes are not general faculties or powers which may be strengthened as a whole by a specific form of exercise.

The forms of training just reviewed were mainly rather narrow in scope. School subjects, such as arithmetic, grammar, Latin, or algebra are appreciably wider, involving memory in several different forms as well as attention, discrimination, judgment, reasoning, and other mental processes. It will be practically important to ascertain to what degree systematic training in repre-

sentative school subjects improves mental ability in general.

The Effects of Training in Geometry

Rugg gave a group of 326 engineers in the freshman class at college a series of tests before and after a semester's training in descriptive geometry. The results of these tests were compared with those obtained from a control group of 87 subjects (72 of whom were in the school of education) who did not study descriptive geometry, but were given the initial and final tests. There were five tests as follows:

(1) Division; such as "divide eighty-one by seven," etc.
(2) Division; such as "divide eight sixty-two by three," etc.
(3) Word-building; making as many words as possible from the letters contained in m-a-t-e-r-i-a-l.
(4) Painted cube test; a three-inch cube, painted on all sides, is cut into one-inch cubes. How many one-inch cubes have paint on three sides? On two sides? On one side? On no side?
(5) Test in geometrical thinking: "Form a mental picture of each object and count the number of straight lines which it would take to construct each one in space." 1. A wedge. 2. Four triangles attached to a square, coinciding with the sides of the square, etc.

In test 1 (division) the control group surpassed the geometry group in improvement; but by only 1.1 per cent. In all other tests, the geometry group exceeded the control group, in amounts as follows: in the second division test, by 15.8 per cent; in the word building test by 19.4; in the cube test by 14 per cent, and in the test of geometrical thinking by 48.5 per cent.

Rugg summarizes the results as follows: "The training effect of such study in descriptive geometry operates

more efficiently in those problems whose visual content more closely resembles that of the training course itself, i.e., in those problems whose imagery content is composed of combinations of points, lines and planes, and in which the continuity of the manipulating movements approaches the continuity of those in the training course." An important outcome of Rugg's experiment, in harmony with others, was the fact that approximately one-third of the engineering group made no improvement in these tests as a result of the semester's training in geometry. Most of the tests used in this investigation were in form or content or both much akin to the functions practised in one form or another by engineering students. The outcome of the investigation then is a demonstration of transfer to functions very similar to those directly trained in amounts which vary with the degree of similarity between them.

In an investigation of reasoning in the case of mechanical puzzles, Ruger obtained evidence concerning the contribution of training in geometry which supplements Rugg's investigation in important respects. Ruger found, for example, that "geometrical concepts played an almost negligible part in the work of solution. This was especially true of tri-dimensional puzzles. What was needed was ability to construct transformations in three dimensions, and the static training in geometry seemed at times even to interfere with the dynamic problem. The concept of symmetry was of some value, but in the main the transfer value of mathematics in so far as it appeared seemed to be largely in the form of general methods, as that of considering the problem solved and working the solution in reverse order. The failure of mathematical training to develop the capacity or capacities for dynamic construction was rather striking."

The Effects of Training in Formal Grammar

An experiment by Briggs, on the spread of improvement from training in formal grammar under school conditions, affords a good example, because of the variety of tests employed, of the degree to which the mind in general is cultivated by systematic education in one line. The investigation was planned to test the hypothesis that grammar trains children:

A. With rules and definitions:

1. To see likenesses and differences.
2. To critically test a definition.
3. To thoroughly apply a definition.
4. To make a rule or definition.

B. With reasoning:

5. To test reasons.
6. a. To take from a mass of data all that are necessary and to use them in reaching a judgment.
   b. To demand all necessary data before drawing a conclusion.
7. To reason in other fields, e.g., arithmetic.
8. To reason syllogistically.
9. To detect "catches."

Fifty-four tests were devised to measure, in some form, each of these nine abilities, and were given to children in each grade from 2 to 7 in the Horace Mann School. Each class was then divided into two divisions. Division I, three times a week for three months was taught formal grammar, while Division II worked on composition and language. At the end of the three months' period, both divisions were given a series of tests similar to the first

series, after which Division II was taught grammar for three months while Division I studied composition and language. At the end of this period the first series of tests was again given to all.

The result may be given in Brigg's words: " . . . it may safely be asserted that these particular children after the amount of formal grammar they had, do not, as measured by the means employed, show in any of the abilities tested, improvement that may be attributed to their training in formal grammar."

Conclusions.—From these representative experiments, there is little evidence that the mind can be greatly strengthened by a limited variety of exercises so that it becomes much more proficient all around. Not only is the mind as a whole not trained as a unit, but a so-called mental process, such as memory, attention, perception, judgment, discrimination, or reasoning is not evenly or generally trained appreciably by a specific form of exercise on a single kind of data. The training of one form of reaction to one class of data frequently does result in some improvement in other functions, especially in those that are similar in form or content or both, but this is not universal, since both zero transfer and negative transfer are not uncommonly found in experimental studies.

A Theory of Transfer

We must now undertake some kind of a general statement to account for the facts as they have been found. What are the factors or conditions that determine the kind and amount of transfer? One general formula—the theory of identical elements—has been proposed by Thorndike.

"The answer which I shall try to defend is that a change in one function alters any other only in so far as the two functions have as factors identical elements. The change in the second function is in amount that due to the change in the elements common to it and the first. The change is simply the necessary result upon the second function of the alteration of those of its factors which were elements of the first function, and so were altered by its training."[1]

Just what is meant by identical elements? Recall that what we learn is a group of minute reactions to a complex situation. If a second situation contains elements that activate some of the same reactions, we may say that the two situations have identical elements and that the amount of transfer from one function to the other is proportional to the amount of identity in the reactions produced by them. The acquisition of reactions to a situation depends, of course, upon the modification of connections in the nervous system, so that identical connections in the nervous system are involved when, and to the degree that, transfer takes place.

The Kinds of Reactions Which May Transfer

It will be useful to consider in some detail the several kinds of identical elements which may appear in two or more situations. During practice in memorizing, for example, a subject may learn a variety of *methods of attack* upon the particular subject matter, as lists of 12 nonsense syllables. He may learn to use a rhythm such as —´◡| —´◡| which is often a useful device. When he changes to the study of lists of words, the general problem, 12 items in a list to learn, may call into use the

[1] E. L. Thorndike, *Educational Psychology*, 1903.

rhythmic division of the items. In this case, the use of the same rhythm probably would be useful but it might be a disadvantage in learning prose or poetry which has a different rhythm of its own. Again, the subject may hit upon the device of learning by the whole rather than the part method, and this may be carried over. He may find that searching for peculiar syllables to serve as landmarks was profitable and this device may be used on other materials, in some cases advantageously, in others not. He may find that, in spite of his initial doubts, his memory is not so bad, and this feeling of confidence may recur whenever any task of memorizing is presented. He may actually acquire greater fondness for trying his skill in memorizing and this satisfaction may be experienced in learning new materials. On the other hand, he may acquire habits of using ineffective associations, of disliking such work, of doubting his capacity to improve, and when transferred these habits would interfere with achievement on new data. What is carried over, then, is not an improved faculty of memory, but new devices, ideas, attitudes, emotions—in a word, a new technique, which may be good or bad in whole or in parts. Habits acquired in one type of memorizing, however, are by no means invariably carried over. The change from non-sense syllables in a list to digits in a row, or to isolated names and dates, or to prose and poetry may offer so few common elements that the subject starts almost anew to acquire a technique fitting the new material.

Unconscious Transfer of Methods and Movements.—Some of the reactions carried over from one function to another are not consciously identified or appreciated. In memorizing, students are often unaware of just what devices they are using, much less of the circumstances

under which they were originally acquired. If one practices hand ball for several years before taking up tennis, it will probably be found that the ability to follow the course of the ball, to estimate bounding, and to make many adjustments of the body, carry over advantageously, while other transferred habits, such as hitting with a snap instead of with a swing may be disadvantageous. Some of the conditions of the new situation elicit reactions previously made to identical conditions in old situations. In a genuine sense they *make* the subject react as he does without awareness, necessarily, on his part of how or why. Similarly, improvement in ability to memorize, observe, or reason consists in a large measure in the development of a number of little tricks of method poorly analysed and poorly understood by the learner, but activated by the common elements of the different situations.

The Transfer of Facts or Information.—In the same category with specific movements, methods of attack, emotional and other attitudes, may be included acquired reactions constituting information or subject matter. During the study of arithmetic, history, or spelling, one may memorize, perceive, and reason; but in addition to the training in these processes one acquires information. Facts learned in one situation may transfer like other reactions, in the sense that they may be utilized in other situations. That knowledge or subject matter is subject to transfer in the same way as movements, devices of learning, and general attitudes, must be made clear, since it is frequently assumed that a fact, once learned, is of universal application—that it floats freely in the mind, ready for use in any situation.

Suppose, for example, that a child unfamiliar with division learns the following tables as they are printed:

A	$2 \div 1 = 2$	$2 \div 2 = 1$	$3 \div 3 = 1$
	$3 \div 1 = 3$	$4 \div 2 = 2$	$6 \div 3 = 2$
	$4 \div 1 = 4$	$6 \div 2 = 3$	$9 \div 3 = 3$
	$5 \div 1 = 5$	$8 \div 2 = 4$	$12 \div 3 = 4$
	....	....	....
	$50 \div 1 = 50$	$50 \div 2 = 25$	$48 \div 3 = 16$

Will the facts of simple division now be available for widespread use? No, they certainly will not. Further practice must be given in mixed orders, to insure the learning of the items independently rather than as lists, for example:

B	$2 \div 2 = 1$	$10 \div 5 =$
	$6 \div 3 = 2$	$2 \div 2 =$
	$10 \div 5 = 2$	$8 \div 2 =$
	$10 \div 2 = 5$	$6 \div 3 =$

When the pupil has mastered these items, he may be unable to solve such problems as the following:

C	10 =	5s
	12 =	2s
	6 =	3s

While the same $10 \div 5 =$ etc., is involved, the situation in general is so different that transfer seldom occurs. The child does not recognize these forms as problems in division. Specific practice having been given in the forms above, will the pupil now be able to compute such problems as these?

D	10 Cents =	Nickels.
	25 Cents =	Nickels.

Assuming that he has not previously learned specifically to compute with money, many children will not make this transfer. Or consider the following:

E 5 cents pays one car fare.
15 cents pays car fares.
45 cents pays car fares.

F For 5 cents you can buy 1 small loaf of bread.
For 25 cents you can buy . . small loaves of bread.

G How many 5¢ balls can you buy with 30¢?
How many 5¢ balls can you buy with 10¢?

Experienced teachers know that with the tables perfectly learned, pupils fail to solve such problems as E, F, and G. The difficulty is that while the arithmetical computations are the same in the several problems, the common elements in the situation are so obscured by other details that they do not become potent except perhaps in the case of a few of the very bright pupils. Facts, in arithmetic or other subjects, cannot be acquired in any one situation in such form as to be generally applicable or transferable. A thoroughly "abstracted" notion of subtraction, or, in other words, generally applicable facility, is the outcome of acts of identifying and practising subtraction in a wide variety of typical situations. To have a general notion of "division" means to be able to realize that this, and this, and this is a case where one should divide. To have a general appreciation of justice or a triangle is to become aware, on facing each relevant situation, that it contains the abstract element in question. In all of these situations we respond to a common, but subtle element. Thus the transfer of ideas—particular, general, or abstract—falls within the concept of identical elements.

The Transfer of General Attitudes and Ideals.—Along with movements, methods of attack and information which may transfer, are more general adjustments, emotional, motor, or mental. Tendencies to maintain calm or to become nervous, to work rapidly or slowly, to be interested or bored, to be self-conscious or absorbed in the task—these, acquired in one situation, may be revived in others by means of common elements. The "problem," "practical," "scientific," or "artistic" attitude may, indeed, be built up to a very wide applicability. But insofar as these tendencies are general, they result from widespread experience, from the acquisitions of habits in

each of many fields, and seldom are they, strictly speaking, universal, as the relative incapacity of most people to deal "practically" or "scientifically" with many problems outside their own field attests.

Implications of the Facts of Transfer

With the main facts concerning the transfer of training before us, how are they to be utilized? What is their implication? How are we to secure the most bountiful general returns from teaching? Three facts, each suggesting a line of endeavor, seem to stand out clearly.

1. Training in *methods* of memorizing, acquiring skills, solving problems, and in maintaining proper attitudes is an important task in education, as well as the mere accumulation of information and skill.
2. The mind and character is trained as a whole only by being exercised broadly in many representative situations.
3. The fact that transfer is greatest to situations which embrace the largest degree of identical elements implies the need of careful scrutiny of the subject matter utilized in education.

The first two statements have been so frequently illustrated in previous chapters that little remains except summary. Great possibilities exist for improving abilities to learn, to profit by reading, to memorize and to solve problems, by definite instruction in effective technique. But by *instruction* more is meant than mere verbal directions to attend to details, work systematically, use the active "recitation" method, maintain calm, verify results, etc. These devices, habits, and ideals must not be taught as a special course, but dynam-

ically fused with the daily work. They should not be given as advice, with the hope of widespread application; they must be *developed* into general habits.

To this end, two requirements must be met. First, the methods, habits, and attitudes must be trained not in one or a few, but in many situations. It must be recognized that each particular task or situation presents its particular difficulties and demands specific adjustment, and it is only by meeting appropriately many situations that general abilities are acquired. Second, in addition to providing diversity and wealth of experience, active efforts should be made to insure a generalization of the desirable methods, facts, ideals and attitudes. They should not be allowed to lie imbedded in particular cases. They should be identified, emphasized, made conscious, and habituated.[1]

How much transfer is obtained, then, depends in a measure on how we are instructed; on how we are led to react and on how well we understand or generalize our experience. It depends, in part, also on the character of the subject matter with which we work.

The Choice of Subject Matter.—For two reasons we may expect a greater transfer to the activities of daily life from subject matter which is itself directly useful in situations commonly encountered outside of school. First, in order to deal with the situations in life, as we saw in the preceding chapter, we need to know the facts involved. We cannot solve problems without information any more than we can play a violin or operate a typewriter without the specific skills, no matter how intelligent or reasonable we may be. Second, the transfer of methods of attack, interest, poise, devices of learning or reasoning, habits or ideals of caution, accuracy, thor-

[1] By such methods as have been discussed in Chapter XIII.

oughness, or initiative to the situations in life will be great to the degree that the subject matter of the classroom is identical with that used in the situations which life itself offers. We should, then, other things being equal, prefer genuine life issues and widely usable facts rather than unreal and fantastic problems, or trivial, unusual, or academic facts. In arithmetic, for example, we should present real problems demanding solutions by the most expeditious and generally practicable methods—rather than problems such as the following, which are preposterous in the facts and misleading in the methods of attack upon real issues which they suggest.

"Alice has 3/8 of a dollar, Bertha 11/16, Mary 3/25 and Nan 3/4. How much have they together?

"There are 9 nuts in a pint. How many pints in a pile of 6,789,582 nuts?

"Suppose a pie to be exactly round and 10 1/2 miles in diameter. If it were cut into 6 equal pieces, how long would the curved edge of each piece be?

"Such problems would occur in real life only in an insane asylum.

"Consider this clever way of finding the thickness of a board:

"A nail 5 inches long is driven through a board so that it projects 2.419 inches on one side and 1.706 on the other. How thick is the board?

"Consider the thoroughness of this horse in eating exactly 16 ounces of hay:

"Just after a ton of hay was weighed in market a horse ate 1 lb. of it. What was the ratio of what he ate to what was left?

"Consider the perfectly fantastic and futile nature of these problems for a problem's sake:

"A man 6 feet high weighs 175 pounds. How tall is his wife who weighs 125 pounds and is of similar build?

"Four bells toll at intervals of 3, 7, 12, and 14 seconds respectively, and begin to toll at the same instant. When will they next toll together?" [1]

Problems which represent real and worthy situations and demand the most sensible and expeditious solutions not only increase respect for and interest in arithmetic but develop information and skill more adequately and make provision for more useful and wider applicability.

There remains the possibility that certain subjects whose contents as such are not widely used in life nevertheless deserve consideration because the kind of activities demanded offer exceptionally effective opportunities for training and disciplining mind and character. Thus it might be urged that football offers exceptional opportunities for the development of courage and sportsmanship, that geometry by the rigidity of its proofs leads to better habits of thought, that Latin because of its difficulty schools concentration and persistence. In each case of this type we must be sure that the subject does train *even specifically* the habits alleged; we must also ascertain possible outcomes, such as distaste for school work, which may also be developed. Finally, we must consider in just what degree habits developed in the subject do actually transfer to others, and recall that insofar as the content is unrelated to life, transfer will be relatively small.

In conclusion, it should be urged that the facts of transfer do not imply that better methods of accomplishing intellectual tasks, or greater zeal, initiative, trustworthiness, and control cannot be developed. On the contrary, they indicate the ways in which desirable adjustments to life may be more surely secured.

[1] From E. L. Thorndike, *The New Methods in Arithmetic*, p. 4 f.

QUESTIONS AND EXERCISES

1. Do you remember any doctrines presented in preceding chapters which seem to be contradictory to the views of the present chapter on transfer?

2. "Skim" the contents of chapters XII, XIII, and XIV, picking out the sections which have a definite relation to transfer.

3. If one spoke English until 10 years old, then spoke only German for 10 years, would the ability to speak English decrease more or less than if one had not spoken at all?

4. A woman aged 30 and her daughter aged 6 came to the United States from France. Why, after two years of practice, does the daughter speak more perfect English (meaning here merely accuracy of articulation) than the mother? If both had secured the same training during the two years, which would probably have developed the largest English vocabulary (knowledge of meaning of words)? Explain.

5. Give other samples of reorganization of bonds, use of old bonds in new functions, and the formation of bonds which may either facilitate or inhibit the old, during periods of no practice.

6. Reread the description of Voelker's experiment on trustworthiness in Chapter XIII. How do the results of that study bear on the problem of transfer?

7. William James, in his chapter on *Habit,* wrote: "As a final practical maxim, relative to these habits of will, we may, then, offer something like this: *Keep the faculty of effort alive in you by a little gratuitous exercise every day.* That is, be systematically ascetic and heroic in little unnecessary points, do every day or two something for no other reason than that you would rather not do it, and so, when the hour of dire need draws nigh, it may find you not unnerved and untrained to stand the test." Examine this statement critically and determine what the conditions would have to be for it to agree with the doctrine given in the text.

8. Would the Law of Effect have any bearing on James's statement? Would the implication of that statement be that subjects should be introduced into the curriculum just because they are difficult or distasteful?

9. Compare the implication of James's statement with the following by Thorndike: "To study the distasteful that is known to

be useful is of much greater disciplinary value than to study the merely distasteful. The habit of value is to *suffer that good may come,* not *to suffer wastefully.* It is in sacrificing for a greater good, not in mere sacrificing, that the mind gains. To suffer simply so as to stand suffering would be as foolish as to learn falsehoods so as to be able to unlearn them."

10. How do you suppose Thorndike would justify this statement: "The greatest disciplinary value of Latin would appear in the case, not of those who disliked it and found it hard, but of those to whom it was a charming game"?

11. Can you think of any mental process or trait of character which cannot be exercised with any but useless facts or situations?

12. Collect some statements from books on education, general reading, or advertisements which are based on erroneous notions of transfer.

13. Suppose it were found in a certain secondary school that the students who had studied geometry were better in reasoning in general than those who had not. Would you consider this satisfactory evidence that training in geometry was responsible for the greater ability in general?

14. Do you think some teachers secure a greater amount of transfer among their pupils than others do? How?

15. Show in detail how the training received in (a) athletic games, (b) grammar, and (c) psychology may be made to function in everyday life.

16. What reactions acquired in playing the piano would transfer to typewriting? To singing? What negative transfer might take place?

17. On the basis of the *general* value of studies, what changes would you recommend in the curriculum of the high school from which you graduated?

18. Will reading good literature contribute to your ability to write? To get the greatest transfer just *how* should you read?

19. How would you train a child to meet emergencies (as in cases of fire, accidents, drowning, etc.)? To what degree will mere knowledge of what to do function in face of an emergency?

20. What subjects are especially useful to develop general open-mindedness or freedom from prejudice and superstition?

REFERENCES

For extensive summaries and discussions of transfer see E. L. Thorndike, *Educational Psychology,* vol. II, chapter 12; Daniel Starch, *Educational Psychology,* chapters 13 and 14; and S. S. Colvin, *The Learning Process,* 1913, chapters 14, 15, and 16.

Three interesting discussions on "Formal Discipline," by J. R. Angell, C. H. Judd and W. B. Pillsbury will be found in *The Educational Review,* vol. 36, pp. 1-42, 1908.

CHAPTER XVI

THE INFLUENCE OF CONTINUOUS WORK, EXTERNAL CONDITIONS, AND DRUGS UPON EFFICIENCY

In this chapter, some of the results of experimental studies on the influence of work, external conditions and drugs, on efficiency and improvement will be given, with little attempt to account in detail for the causes of the effects observed. In most instances the detailed ways in which the effects are brought about are not known, and even when they are known, descriptions of the causations are more complex than is necessary for our purposes.

The Influence of Work and External Conditions

Continuous Muscular Work.—The effect of continuous work in a function upon efficiency in it, as measured by the amount and quality of the product (words written, facts learned, etc.), varies considerably with the function.

In the case of hard muscular work the fall in efficiency is rather steady and pronounced. Figure 38 shows the relative distances through which the middle finger pulls a load of about six and a half pounds making a pull every two seconds. The muscle soon is incapable of lifting the load although it is not entirely exhausted as is shown by the fact that it can still lift smaller weights. A rest of about two hours would be required before the muscle could repeat the original performance. If sufficient rest is given between the contractions, the muscle

will lift the load a much greater number of times. If a muscle in some other part of the body, the other arm, for example, is working at the same time, the finger loses its strength more rapidly possibly because of the fatigue products circulating in the blood. Loss of sleep or food, and doses of alcohol and certain other drugs, decrease the

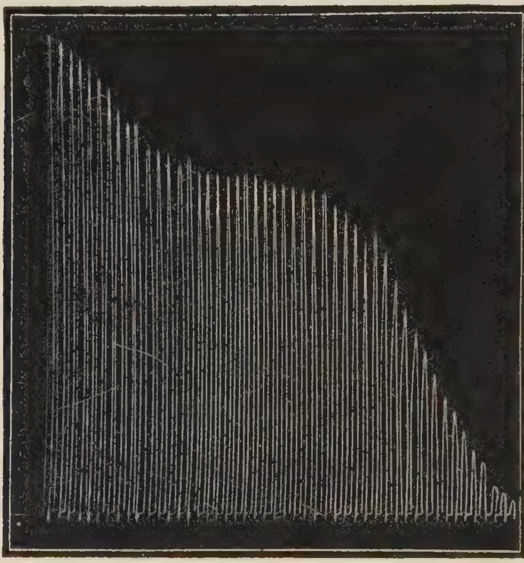


FIGURE 38. The vertical lines indicate the relative distances through which a weight of 6½ pounds is pulled by the middle finger of the right hand. Contractions were made at intervals of two seconds. (From Howell's, *A Textbook of Physiology,* 5th Edition, p. 48.)

efficiency of the muscle, whereas sugar, adrenalin, and certain other chemicals increase efficiency.

Muscular work of this sort uses up definite materials such as glycogen and develops by-products such as carbon dioxide, which together reduce the capacity to function. Unpleasant sensations, pain, or so-called "feelings of fatigue" are also produced, along with definite impulsions to cease the work.

Continuous Work of the Neurones.—The effect of continuous work by isolated neurones may be observed experimentally. One method employed is to dissect from a freshly killed frog a large muscle with a long motor nerve (bundle of motor neurones) attached. Such a "nerve muscle preparation" can be kept alive for a long time. If the stump of the nerve is stimulated by an electric shock, the nervous impulse thus occasioned discharges into the muscle and causes a contraction. If contractions are provoked rapidly, the muscle soon fails to respond. Whether the loss of capacity is due to fatigue of the nerve or to fatigue of the muscle may be determined by an experiment. If a bit of the drug curari is placed on the nerve near the muscle, the nerve impulse is blocked at that point so that it fails to activate the muscle. It has been found, however, that the impulse passes along the nerve, as far as the point at which the drug is applied, i.e., that the neurones are conducting as under ordinary circumstances. Investigators have found that even when the nerve is stimulated several times per second for ten hours or more, removal of the effects of curari results in the renewal of the muscular contractions upon stimulation of the nerve, thus demonstrating an extraordinary resistance to "fatigue" on the part of nerves as compared to the fatigability of muscles.

Continuous Mental Work.—Mental work usually involves the activity of muscles as well as neurones of the central nervous system. In reading, the muscles of the eyes, at least, are engaged; in writing compositions and in arithmetic, the muscles of the eyes, hands, and arms are active. Even in "mental" arithmetic, spelling, or ordinary thinking, muscles of the eyes, the vocal organs, and probably other parts of the body are involved to some

extent. And in all types of mental work, the maintenance of the body's position depends upon muscular adjustments. Thus, what we call "mental fatigue" is in part the result of muscular work and identical with muscular fatigue.

When one has been working continuously at spelling, arithmetic, reading, composition, or some other mental task, he may become aware of a group of sensations which technically have been called "feelings of fatigue," usually unpleasant in character. Feelings of fatigue are, in a large measure, sensations from muscles, tendons, and joints, and include feeling of numbness, aches, and pains from the eyes, head, back, and other parts of the body. With these are fused other sensations derived from visceral, arterial, and other organic conditions. The whole constitutes the familiar feeling of fatigue which is ordinarily accompanied by impulses to stop working. If the work is continued it becomes tedious, unpleasant, or aggravating.

The progressive course of feelings of fatigue and annoyance produced by continued work is pictured roughly in Figure 39, which is based upon the judgments of a group of adults obtained during four hours of continuous work in grading English composition. Highly interesting at the beginning, the work became progressively less pleasant, until at the end of the fourth hour it was clearly distasteful.

Feelings of fatigue and loss of interest are commonly accepted by workers as indicative, at least approximately, of a decreased state of efficiency. But that these symptoms are extremely misleading has been found repeatedly when the quantity and quality of the output has been measured during periods of continuous work. In Figure 39, the distastefulness of the work in the case

of grading compositions, for four hours continuously, is plotted together with the output. The loss of ability is not nearly as great as the loss of satisfaction in the work.

Many investigations of continuous mental work have yielded similar results. Two or three hours of continuous work at maximum effort produces a temporary decrease in the product of not over ten per cent, and in most functions less than that. By a temporary decrease

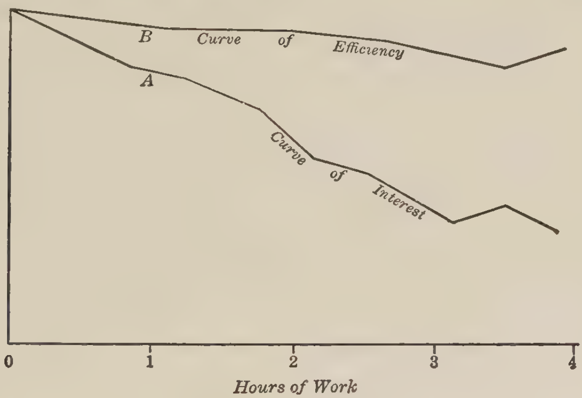


FIGURE 39. Curve *A* shows the rapid loss of zeal or interest in grading English compositions during a period of 4 hours. The curve is an average for 5 subjects. Curve *B* shows the loss in efficiency, represented by a combined score for speed and quality of work, during the same time by the same subjects. The greatest loss (near the end) is about 7 per cent. (Modified after Thorndike.)

is meant one which is curable by a rest of an hour or less. Of course, the curve of work is marked by all sorts of fluctuations, some of them peculiar to particular individuals, and efficiency may drop more decidedly if the worker eases up. But on the whole, continuous work in mental functions shows a small loss in output as compared to that found in continuous muscular work. If we make mental work as difficult as we can, taking for our task the mental multiplication of such numbers as 8372

and 3458, for example, we find that, as demonstrated by one experimenter, it is possible to keep it up for 12 hours at a stretch. The result of long continued difficult mental work is thus in sharp contrast to the effect of hard physical work. While feelings of physical fatigue may be fair indices of physical capacity, they yield by no means reliable evidence of mental efficiency.

So far as mere loss of efficiency is concerned, there is little to urge against long continued work of the same sort. But what of other effects? Too lengthy application to a task *may* make the work uninteresting, or positively repugnant. When the work becomes distasteful or exasperating, it probably indicates an unfavorable organic stirring-up somewhat similar to that observed under emotional irritation or excitement. This general state is indicative of a considerable organic wear and tear which may become injurious if long continued. But it is the repugnance, exasperation, excitement, or worry produced by mental work rather than the work itself which is harmful. If one can school himself to maintain interest and enjoyment in the task, the ill-effects of long and hard mental work may be tremendously reduced. There are, of course, limits to the amount of mental work one may safely do because of the muscular fatigue and the deprivations of recreations, exercise, rest, and sleep which too persistent work may bring. Just how long a person may safely do mental work depends partly upon his general strength and stability, partly upon his susceptibility to excitement and worry, and partly upon his interest. In school practice, short periods and frequent changes of work are advisable, not mainly because they are needed to secure improvement, but because they make school life more interesting through variety.

The "feelings of fatigue" are in part, if not mainly,

the results of muscular activity and strain. Much may be done to lessen unnecessary and often damaging fatigue, particularly of eye and hand. For example, the task of copying problems to be computed in arithmetic, poems to be memorized, etc., is not only harder work, minute for minute, than computing or memorizing, but much more monotonous. It is, moreover, as unnecessary as it is fatiguing. Less worry about the disastrous effects of "mental fatigue" and more attention to muscular fatigue of eyes, hands and the body is one suggestion which the experimental studies of mental work have to offer.

The Course of Efficiency During the School Day.—Under the conditions of an ordinary school day, what is the relative efficiency in mental and motor performances at different hours? In one investigation, the pupils of several grades were repeatedly tested in representative tasks at different periods until the accumulated results gave a fairly accurate measure of achievements resulting from maximum effort at different hours of the day. The results are given in the table on the following page.

In the more strictly mental functions such as addition, multiplication, visual and auditory memory, recognition and completion, efficiency is lowest in the first and highest in the last morning period. A slight drop follows the lunch period with a subsequent rise between two and three o'clock. Other investigations have shown a very similar distribution of efficiency for gross bodily functions, such as shoveling and lifting. Efficiency in motor skills, such as cancellation and tracing, is somewhat greater in the afternoon than in the forenoon.

Similar average results were obtained from a group of college students tested at all hours, except noon, from eight A.M. to five P.M. An interesting feature of this

Variation in Efficiency During the Day (From Gates)

THE ACHIEVEMENTS AT THE SEVERAL HOURS ARE PROPORTIONAL TO THAT AT THE 9-10 A. M. HOUR WHICH IS 100.0 IN EACH CASE. AVERAGE RESULTS FOR 240 PUPILS FROM GRADES 5 AND 6

TIME	9-10 A.M.	10-11 A.M.	11-12 M.	12-1 P.M.	1-2 P.M.	2-3 P.M.
1. Addition	100.0	102.4	104.2	....	102.3	103.0
2. Multiplication ..	100.0	101.9	105.1	....	100.9	103.0
3. Memory for Auditory Digits..	100.0	105.9	106.7	....	99.4	102.4
4. Memory for Visual Digits....	100.0	103.2	109.2	....	99.1	103.4
5. Recognition of Non-sense Syllables	100.0	104.7	105.3	....	100.0	103.7
6. Completion	100.0	105.0	109.7	....	106.2	108.8
Average	100.0	103.8	106.7	....	101.3	104.1
7. Cancellation	100.0	101.8	104.4	....	104.9	105.5
8. Speed and Accuracy of Tracing	100.0	104.6	106.7	....	109.5	111.2
Average of 7 and 8	100.0	103.2	105.6	....	107.2	108.4

investigation was the disagreement between the distribution of actual ability and the distribution of self-judged ability. Most students were quite mistaken about the hours of their maximum efficiency, doubtless because they were misled by feelings of fatigue which were often most acute at the periods of highest efficiency.

One thing is quite certain: the ordinary work of the school day is not so severe as to reduce efficiency perceptibly. In fact, achievement is higher at nearly every hour than it is at the beginning of the day. In the main, the differences are small. Aside from the suggestion that such functions as writing, drawing, or other light work

requiring speed and accuracy of movement might well be given in the first afternoon period, it would appear to make little difference when reading, arithmetic, and other studies are conducted.

"Bad Air."—It is popularly believed that in poorly ventilated rooms, carbon-dioxide and other toxins from expired air result in drowsiness, lassitude, headaches, and loss of efficiency. Pure air contains about 21 per cent of oxygen, 78 per cent of nitrogen, and 0.03 per cent of carbon-dioxide. In a very crowded and ill-ventilated school room the carbon-dioxide may be increased to 0.3 per cent. and the oxygen decreased to 19 per cent., but these changes are insufficient to produce the effects ordinarily observed. When the air is cool, of favorable humidity, and in movement, the oxygen content must be reduced to at least 14 per cent. or the carbon-dioxide increased to 2.4 per cent. before ill effects are produced. When the air is hot and of unfavorable humidity, the ill effects are not relieved by breathing pure air through a tube from the outside. High temperature or humidity, or both, then, rather than low oxygen content and expired matter, seem to be the causes of discomfort.

Temperature and Humidity.—The influence of stale air, high and low temperature and humidity in various combinations has been studied by Thorndike and several psychologists working under the auspices of the New York State Commission on Ventilation.

It was found that adult subjects when urged to do their best could perform quite well and improved in efficiency quite as much when working in hot, humid, stale, and stagnant air (temperature 86° Fahrenheit, humidity 80 per cent, with no fresh air and no movement in the air) as when they were working under "optimum" conditions—namely, a temperature of 68° Fahrenheit, 50

per cent relative humidity and 45 cubic feet of outside air each minute for each person. It was furthermore found that when the subjects were given very uninteresting work and were given no incentives to do well but were, on the contrary, tempted to relax standards, they still did as much and as well when working eight hours a day in the hot, humid, and stale air as when working under optimum conditions. Finally, when individuals were given their choice of doing mental work, reading stories, resting, talking or sleeping, they did quite as much work when the temperature was 75° as when it was milder, 68° Fahrenheit.

The influence of extremely low humidity, with temperature kept constant at 75° Fahrenheit was found by Stecher to have no perceptible effects upon efficiency or improvability. A squad practising arithmetic, typewriting, and other functions during the regular working day with the humidity reduced to 20 per cent. improved as rapidly as a squad working under the "ideal" degree of humidity, 50 per cent.

The atmospheric conditions which are encountered in ordinary life, then, however uncomfortable some of them may be, have no appreciable effect upon efficiency in performance, or on improvement in mental and light motor work. Whether long continued exposure to very hot, very moist, or dry air would occasion a good deal of wear and tear on the body or injure health, is another problem not as yet solved. The results of the psychological investigations indicate merely that if one must face severe atmospheric conditions, as in mid-summer, one had best do so cheerfully, as it is unlikely to be too hot to make mental work unprofitable. If one will, one can learn as well when it is hot as when it is cool, when it is moist or dry, as when the humidity is moderate.

The experimental studies have a bearing on the perennial topic of the effects of weather and climate upon human feelings and efficiency. That human beings do become adapted rapidly to the most forbidding climatic conditions of the globe is not surprising in the light of experimental studies in which adjustments are effectively made to abrupt and extreme changes in humidity, temperature, and staleness. While climate and weather includes in addition to these factors others such as density of the atmosphere, light, and possibly electrical conditions, the probability is that adaptation to these is equally facile.

Illumination and Color.—The most essential feature of favorable illumination is an evenness of distribution of light, especially the absence of glare, or contrast, in the field of view. Artificial or window light should therefore come from above, behind, or at the sides. Contrasts in walls and hangings, glistening paper, or polished instruments contribute to eye fatigue. A second desirable feature is illumination of moderate intensity. Lights are more often too bright than too dim. Particularly unfavorable intensities and brightnesses are often produced by the use of high power electric lights. A soft even light from indirect or semi-indirect systems is most satisfactory.

There are many opinions concerning the effects of colors of lights or surroundings on efficiency, disposition and health, but the findings of experimental investigations have been mainly negative. The most significant difference between light from an uncolored globe and light from a colored globe is that the colored light is less intense—the colored glass absorbs some of the rays. Some have found that the more intense light is more stimulating, but the difference is small. What little is

gained by means of the stimulating effect of intense light is probably more than compensated for by its fatiguing effect upon the eyes. Colored glasses are restful only because they reduce light intensity. It makes little difference what particular colors are used.

Auditory Distractions.—Just as the organism becomes adapted to wide differences in light or temperature, so it becomes adapted to persistent sounds of the street, conversation, rattling of typewriters, or the roar of machinery. When adults are well adapted to a working condition, new distractions are apparently at first disturbing, although they have little effects on the output. Experiments conducted in the laboratory indicate that when a subject is well adapted to a working condition, the introduction of a new disturbance causes but a slight and temporary decrease in efficiency, although it may be decidedly annoying. The subject soon arouses himself to overcome or adjust to the noise. His output is then kept up to the norm, often actually surpassing it, but in so doing more than ordinary energy is consumed. He may pound the typewriter keys harder, grit his teeth, articulate, and contract various muscles. These superfluous activities drop out gradually as adjustment is perfected, just as irrelevant reactions tend to be eliminated in all forms of trial-and-error learning. The general rule seems to be that when a new disturbance is encountered, the worker sets about to acquire by trial and error an adaptive reaction to it and succeeds in so doing without appreciable deterioration of his output during the process.

General Conclusions.—Other types of experimental evidence on the remarkable capacity of the organism to adapt itself to unusual conditions have been obtained. For example, students during periods of from 30 to 48 hours without sleep, although subject to pronounced

"feelings of fatigue" and other uncomfortable symptoms, were nevertheless able to perform mentally as efficiently and learn as effectively as under ordinary conditions. During a fast of 31 days, a man studied by Langfeld showed no appreciable loss of mental efficiency and ability to learn, although the decrease of bodily weight and strength was great.

Some of these adaptive reactions—to heat, cold, low humidity, continuous work, loss of food—appear to be directly instinctive; that is, they are carried out as in the case of the infant, by adjustments inborn rather than learned. The adaptations to new noises, or visual distractions, while involving instinctive acts, are nevertheless, in a genuine sense, acquired. The process of overcoming an auditory distraction affords, as we have said, a beautiful example of the trial-and-error learning in which elimination and selection continues until the adjustment becomes easy, smooth, and nearly unnoticed. That these adaptations are, however, really active adjustments is indicated by the fact that when the stimulus, to which an individual is adapted so completely that it is unnoticed, *is removed,* he becomes aware of the change and must make another adjustment to the rearranged conditions. Thus, when one is adapted to a certain rattle or roar in his working environment, removal of the sound may be temporarily disturbing, although readjustment is shortly achieved.

The "emergency mechanism," innervated by the sympathetic system described in Chapter VIII, may be and doubtless is frequently brought into action under the stimulus of high temperature, noise, and other unusual conditions. In some cases, these profound internal changes may be serviceable; in others, not. It is quite characteristic of compensatory reactions to go too far.

The subtle processes of our inner mechanisms in repairing wounds, enclosing bacteria, etc., frequently so overdo the task as to cause greater ills than they remedy, as every surgeon knows. Similarly the sympathetic system, which doubtless often becomes active, may bring about its disruptive effects during adjustment to external conditions. The sympathetic system is, to some extent, however, subject to voluntary control. To develop habits of remaining calm even if we must work occasionally under trying conditions is plainly a desirable thing to do. Better to work than worry, and to become interested in work is one of the best ways of avoiding worry and excitement.

The Influence of Drugs

Caffeine.—Caffeine is the active drug in tea, coffee, and many soda-fountain drinks. An average cup of hot black tea contains 1.5 grains; an after-dinner coffee about the same; an average glass of cold green tea about 2.0 grains; and a large cup of coffee about 2.5 grains.

Employing a squad of 16 subjects whose food, sleep, rest, and work was controlled during an experiment which extended over 40 days, Hollingworth measured the influence of doses of caffeine ranging from two to six grains upon various mental and motor functions. The effects of suggestion and anticipation were eliminated by administering the drug in disguise. At uniform intervals the subjects were given a mixture which sometimes contained and at other times did not contain the caffeine.

The effect of a dose of caffeine appears usually within an hour and lasts for several hours, depending on the size of the dose. This substance usually produces a decrease in muscular steadiness with tremors, which appears more quickly and lasts longer with larger doses. In typewriting, greater accuracy results from using the drug, while

speed is also increased except by large doses, which reduce the rate of writing. In more purely mental work—naming the opposites of words, naming colors, adding, etc.—efficiency was increased by doses of all sizes for periods varying from three to seven hours. In the task of crossing out certain numbers from rows of mixed numbers doses of four grains or more produced improvement in ability which sometimes persisted for nearly 24 hours. The stimulating effect of the drug was indicated by the fact that a dose of six grains disturbed the sleep of most subjects, and on some much smaller doses had a similar effect. The stimulating influences of caffeine, contrary to general opinion, is not followed by a subsequent period of depression, at least not within 72 hours.

It should be understood that tea, coffee, and other caffeinic beverages contain other substances which may enhance or neutralize the effects of caffeine or produce still other effects, good or bad. What influence the long continued use of this drug may have on the body is not known, but during a period of 40 days, insofar as integrity and proficiency in mental work are concerned, caffeine has distinctly an accelerating effect without any observable harmful results.

Tobacco Smoking.—No unquestionable evidence of the influence of tobacco smoking on efficiency in and improvement during work has as yet been published, for the reason that a perfect control has not been devised. If habitual smokers are used as subjects, the mere deprivation of the exercise of the habit may disturb their attitude toward work. If subjects unaccustomed to smoking are used, the effects of tobacco will be obviously not typical of the average smoker. Statistics gathered concerning groups of smokers and non-smokers are interesting but worthless, because the groups may differ in

many other habits as well as in the use of the tobacco. The facts can be secured only by trying out various groups of subjects, who are compared with similar groups not exposed to the experimental factor. If we are interested in the effect of tobacco alone, it is essential that the subject should not know when he is really getting tobacco and when he is getting something else, since the mere idea of smoking, the pleasure of the act, or the stimulation provided by the sight, taste, and smell, may produce the result rather than the drug itself.

These conditions have as yet not been faithfully fulfilled in the case of tobacco, although a good many less adequate investigations have been made. The outcome has been fairly consistent, indicating a deleterious effect both on mental and motor achievement, in complex functions at least.

A sample result is given in the accompanying table. Fifteen smokers were given a test, following which they smoked quietly for 15 minutes, and then took the test again. Two non-smokers served as controls, taking the tests at the same time, one smoking supposedly harmless "cubebs," the other not smoking at all. The gains, indicated by +, and losses, indicated by —, are shown in percentages in the table.

Effects of Smoking (From Bush)

TESTS	AVERAGE GAIN OR LOSS OF 15 SUBJECTS WHO SMOKED TOBACCO. PER CENT.	GAIN OR LOSS OF ONE SUBJECT WHO SMOKED CUBEBS. PER CENT.	GAIN OR LOSS OF ONE SUBJECT WHO DID NOT SMOKE. PER CENT.
Speed of Perception	— 17.1	— 6.8	+ 3.4
Free Association ..	— 8.7	— 20.5	+ 0.2
Addition	— 9.4	+ 9.4	+ 1.2
Subtraction	— 6.7	— 0.8	+ 1.0
Average of 9 tests (5 not given above)..	— 10.6	— 4.2	+ 2.7

If the results are typical, the adult must pay the price for indulgence in smoking by some loss in achievement. Concerning the effects of tobacco upon general health, there are opinions in abundance, but no reliable evidence.

Alcohol.—The influence of alcohol, administered in its pure form diluted with water or beverages, upon efficiency in various mental and motor functions has been investigated on several occasions with results which agree in the main. An English psychologist, Rivers, was the first to disguise the alcohol properly so that the subject was unable to tell by look, taste, or smell whether the mixture contained alcohol or another harmless substance. Rivers employed tests mainly of muscular efficiency, strength, and endurance, upon which little effect was produced except by large doses of alcohol. Effects found in earlier investigations were attributed to sensory stimulation (tastes, odors, sting) or to expectation of improvement rather than to the drug itself.

Dodge and Benedict, during extensive and carefully controlled investigations in the Nutrition Laboratory of the Carnegie Institute, found that alcohol had not a stimulating but a depressing effect upon mental and motor efficiency. To this statement there was one exception—the pulse was accelerated, which was symptomatic, perhaps, of internal resistance to the drug. In the case of several functions, the losses of efficiency which resulted from doses of 30 and 45 cubic centimeters of alcohol—the results for doses of both sizes combined—were as follows:

Knee-jerk: decrease in extent of muscle contraction..	46 per cent
Knee-jerk: increase in time of reaction............	10 per cent
Protective eye-lid reflex: decrease in extent.........	19 per cent
Protective eye-lid reflex: increase in time..........	7 per cent
Sensitivity to electric shocks: decreased............	14 per cent

Speed of eye movements: decreased.................	11 per cent
Speed of tapping, with hand: decreased.............	9 per cent
Speed of reading isolated words: decreased..........	3 per cent

In all tests, the effect of alcohol is to reduce functional capacity, and this is strikingly true of the simple protective reflex activities which become more sluggish in rate and less effective in extent. No representative tests of mental efficiency were employed by these workers.

The influence of alcohol on both motor and mental functions has been recently investigated by Hollingworth. The alcohol dosage was administered in the form of beer which was 2.75 per cent. alcohol by weight. Six trials of each test were given during the forenoon. At noon the beer was given with a small amount of food. On certain days beer was given which was identical in all respects with the genuine except that the alcohol had been removed, thus providing a control. During the afternoon, six trials of each test were again given. In the accompanying table, the gains and losses of efficiency due specifically to alcohol are given in terms of percentages.

TEST	BEER CONTAINING TOTAL OF 40-50 CC. ALCOHOL	BEER CONTAINING TOTAL OF 66-79 CC. ALCOHOL
Pulse-rate	+ 8	+ 10
Steadiness	−68	−241
Tapping	− 7	− 13
Coördination	— 6	— 10
Color naming	− 2	− 7
Opposites	− 5	− 12
Adding	−10	− 15

The loss of efficiency due to alcohol is universal and pronounced among the functions tested, with the exception of the rise in pulse rate. Coördination of motor control and speed of tapping are appreciably reduced; steadiness is more markedly disturbed. For all of these

motor functions, the effect of the large dose is greater than that of the small. On mental efficiency, the drug has a similar disastrous effect, similarly proportionate to the size of the dose.

The singular rise in pulse rate, which was also observed by Dodge and Benedict, is probably a symptom of the arousal of internal mechanisms to combat the damaging effects of the drug. In support of this hypothesis was the finding that those subjects whose mental and motor control were least influenced by the drug showed the greatest increase in pulse rate; those most disturbed showed the slightest increase in pulse rate.

Other Drugs.—*Strychnine* in fairly large doses (1/5 to 3/15 grains) seems to lead to a temporary increase in ability to run a complex machine (dotting machine) and in capacity to memorize, often followed by a decrease to less than normal capacity unless the dose is repeated. Very small doses, 1/30 to 1/20 grain, according to Poffenberger, produce negligible results on speed of tapping, aiming, and a wide variety of mental functions. *Opium* and *morphine* appear to cause an initial stimulation which appears slowly and rises to a maximum, and then efficiency descends below—sometimes considerably below—normal. *Cocaine* causes a large immediate stimulation followed by a period of pronounced depression. Because of its immediately stimulating effects it has become a great favorite among drug addicts.

Conclusions

The experiments here given disclose only the immediate effects of external conditions and drugs. It would be unsafe to conclude that influences showing great immediate effects upon mental efficiency and skill would have a corresponding serious effect upon general health or

upon particular bodily functions and organs when used continuously. It would be likewise unsafe to conclude that influences whose immediate effects are slight or zero would produce, when continuously used, no general or specific ill results. To determine the outcome of the habitual use of drugs or of habitual exposure to unusual environmental conditions constitutes another and more difficult problem. Of no mean importance, however, is the finding that not unusual doses of alcohol, caffeine, strychnine, and other drugs disturb mental and motor efficiency at once and more profoundly than deprivations of food or sleep, or exposure to natural extremes of atmospheric conditions, or to visual and auditory distractions. These substances richly deserve their name—"powerful drugs."

QUESTIONS AND EXERCISES

1. Show how the laws of learning may be applied to the breaking up of the habit of excessive tobacco smoking.

2. Collect the opinions of ten people of your acquaintance concerning the effect of caffeine on efficiency. What reasons do they give for their views? Contrast such evidence with the conclusions drawn from scientific experimentation.

3. What are the real reasons why good ventilation is important in a school-room? The false reasons?

4. Give illustration from your own experience of (a) a situation where feelings of fatigue preceded loss of efficiency; (b) a situation where loss of efficiency preceded feelings of fatigue; (c) a situation where the decrease of worry and excitement increased mental ability; (d) a situation where the elimination of unnecessary muscular fatigue made an increased amount of mental work possible.

5. At what time of the day do you think you can perform mental work most efficiently? Plan in detail an experiment to test this opinion. What precautions would it be necessary to observe? (See A. I. Gates, "Diurnal Variations in Efficiency, etc.," University of California, *Publ. in Psychology,* Vol. 2, No. 1, 1916).

6. Do the experiments on temperature and humidity have any bearing on the problem of the difference found between races living near the equator and races living nearer to the poles?

7. Diagram roughly what happens in the nervous system when an individual learns to disregard a distracting stimulus. (See Chapter X.)

8. What are the specific effects of an emotional upset due to poor working conditions? (See Chapter VIII.)

REFERENCES

H. L. Hollingworth and A. T. Poffenberger, *Applied Psychology,* 1917, Chapters 6 to 9 inclusive.

J. B. Watson, *Psychology,* 1919, Chapter 10.

E. S. Robinson, *Mental Work,* a review of the literature, in the *Psychological Bulletin,* vol. 18, pp. 456-483, 1921.

CHAPTER XVII

THE NATURE OF INDIVIDUAL DIFFERENCES

Individuals of the same age differ greatly in every trait that has been measured or estimated. In height, weight, and strength; in susceptibility to disease, nervous stability and mental balance; in intellect, character, and skill; and in aptitudes for special subjects, arithmetic, spelling, music, or athletics individual variations are found. These facts have been implicitly assumed in the discussions of the preceding sections; in the present chapter they will be treated with more precision.

The differences between members of the human species are quantitative. People are qualitatively the same in the sense that they have in some degree the same instincts, emotions, and capacities to learn, to perceive, remember, imagine, reason, and to be satisfied and annoyed. The physicists have analysed the "qualities" of tones of the human voice, of the violin, and of other instruments, finding that the most subtle variations are due to the quantities of many constituent tonal elements which have been identified and measured. So with human traits, final analysis will probably show all variations to be due to quantitative combinations of specific abilities, which sooner or later, may be discerned and measured. A human trait, such as initiative, vivacity, or trustworthiness, is, in the case of each individual, a composite of many kinds of abilities each present in a definite amount.

Tables and Surfaces of Distribution

The best form of introduction to the facts of individual differences will be the study of a sample of the results of measurement. In the accompanying table are given the scores obtained by the pupils of the fifth grade in an arithmetic test:

SCORES	PUPILS
12	F
11	
10	X
9	WB
8	LCE
7	AKSDL
6	OPTU
5	RMHI
4	QV
3	N
2	G

When the data are given numerically as in the table below, we have a *table of frequency* or a *frequency distribution,* in which the scores are listed in the first column and the number of pupils receiving each score in the second column.

SCORES	NUMBER OF INDIVIDUALS
12	1
11	0
10	1
9	2
8	3
7	5
6	4
5	4
4	2
3	1
2	1

The data of this table may now be displayed graphically in a *frequency surface* or *surface of frequency.* A

surface like Figure 40 is usually called a *frequency polygon.* When the mid-points of the tops of the rectangles

FIGURE 40. A frequency polygon based on the data of the table above. The horizontal line shows the scores in the test; the vertical column at the left gives the number of individuals or frequency. The heights of the blocks in the diagram thus show graphically the frequency for each score.

are joined, as in Figure 41, the surface is called a *frequency curve.* The sole purpose of using a frequency

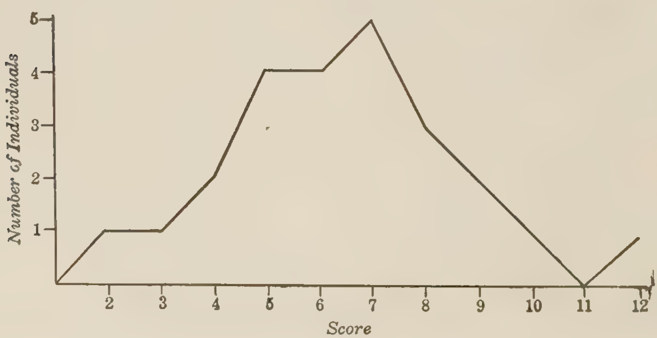


FIGURE 41. A frequency curve, constructed by joining the mid-points of the blocks of Figure 40.

surface or curve is to provide a more comprehensive picture of the form of distribution.

The Amount and Character of Individual Differences

In this grade, the differences between the best and poorest pupils are considerable, but about one-half of the pupils receive scores 5, 6, or 7; that is, the group clusters about a mid-point, from which there is a scattering to each extreme. With the exception of score 11, which would have occurred, without doubt, in a larger group, every score between the extremes is represented by one or more pupils. In the distribution of these small groups we find, then, rough illustrations of the main facts of individual differences: (1) that the variations among pupils of similar circumstances (age or grade) are wide; (2) that the variations are continuous; and (3) that they cluster around a central point or mode.

An idea of the range of abilities that may be found in a single grade in representative school functions is given in the accompanying table:

Abilities of the Best and Poorest of a Class of 30 Pupils, Grade 6

	BEST	POOREST
Reading, words per minute	35.0	8.7
Reading, comprehension, Thorndike test score	28	12
Writing, words per minute	96	38
Arithmetic, addition, number examples right	36	19
Arithmetic, subtraction, number examples right	34	20
Arithmetic, multiplication, number examples right	34	18
Arithmetic, division, number examples right	30	14
Word knowledge, score	85	30
Spelling, number of words from list of 100	96	40

The quickest reader covers over three times as much material per minute as the slowest; the best in addition does nearly twice as many problems as the poorest; one pupil defines nearly three times as many words as does another, and similar variations are found in other sub-

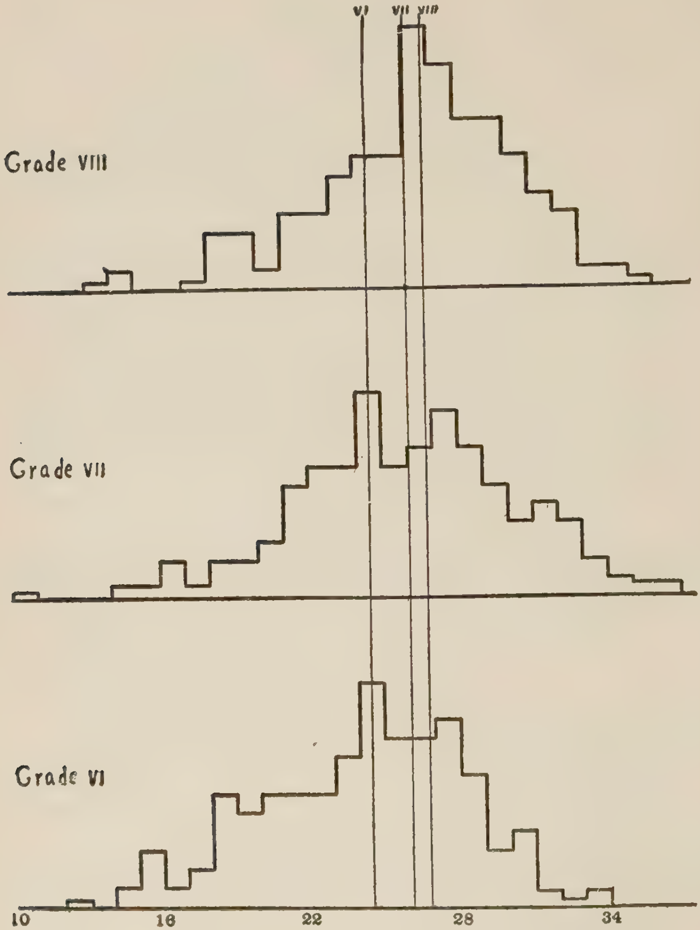


FIGURE 42. Frequency polygons for ability in division. There are 234 pupils in the grade 6 group, 307 in grade 7, and 272 in grade 8. The vertical lines headed by VI, VII and VIII indicate the average abilities of the respective grades. Note how slight the differences between the grade averages are and how much each grade overlaps the others. (From Kruse, *The Overlapping of Abilities in Certain Grades,* p. 41.)

jects. These differences are very important practically. The materials for study and the methods of studying

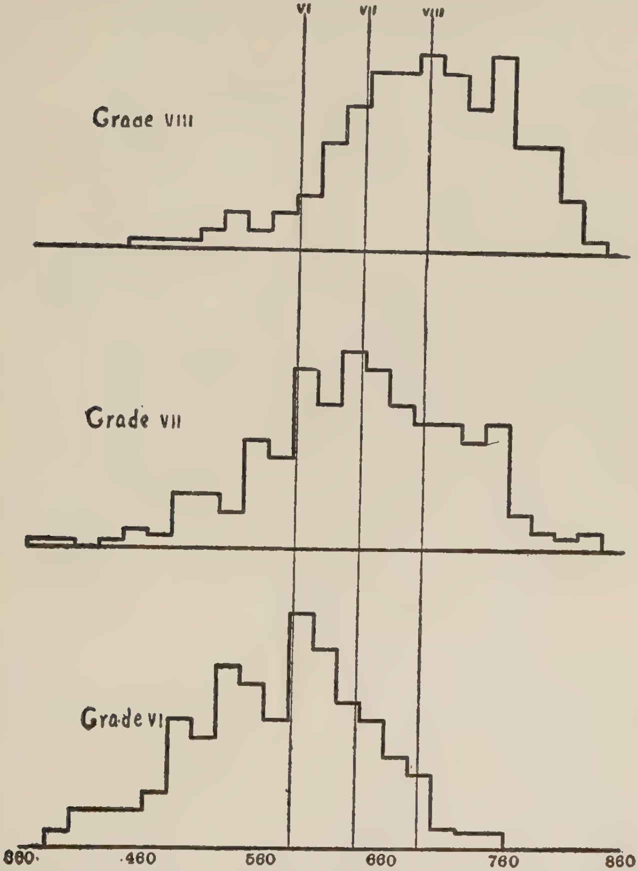


FIGURE 43. Frequency Polygons for Composite scores in 22 different mental and educational tests. There are 254 pupils in the grade 6 group, 324 in grade 7 and 282 in grade 8. Compare these graphs with those in Figure 42 for range of abilities shown and for the amount of overlapping of one grade on another. Note that the differences between the averages of the grades are greater than those shown in Figure 42. (From Kruse, *op. cit.*, p. 53.)

suitable for the best students are often but poorly adapted to the use of the poorest in the same grade.

The variations of abilities in school grades may be shown more clearly and completely by surfaces of frequency which show the status, not merely of the extremes, but of all the pupils. In Figure 42 are shown the distributions in three grades. In each the distribution is wide and rather irregular. The irregularity of the curves is due partly to the small size of the groups and partly to the incompleteness of the measures. If each function were tested with greater thoroughness the range of abilities would usually appear somewhat less great. Furthermore, the variations in a grade are likely to be greater in a particular subject than in a composite rating for all subjects, since pupils are classified mainly on the basis of general attainments. Many may be admittedly above or below the average in writing, arithmetic or some other subject. In Figure 43 the results of twenty-two tests in several representative subjects are averaged. This graph gives a very fair notion of the variations

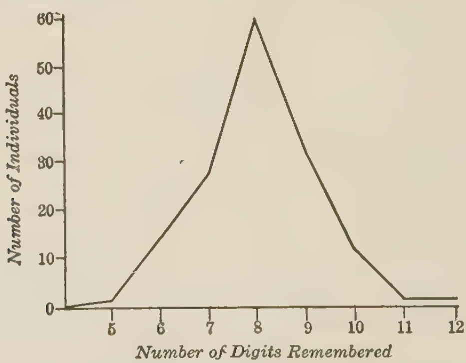


FIGURE 44. Distribution of ability to remember series of digits shown at the rate of one per second. The horizontal line shows the longest series remembered. The vertical line shows the number of individuals of each ability. Based on 165 college students.

among pupils in the same grade in general scholastic attainments. While the range is here less extensive

than in graphs portraying the results of tests in a single subject, it is still very great.

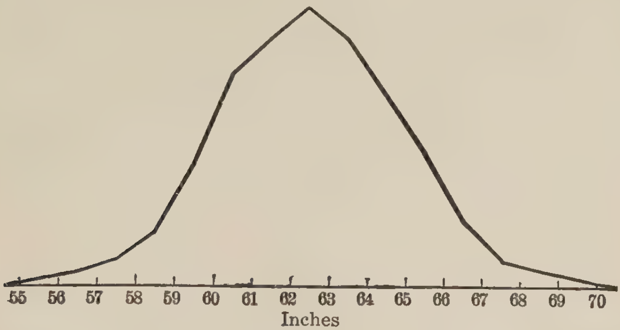


FIGURE 45. Distribution of the height of 1,052 women. (From Starch, *Educational Psychology,* p. 31.)

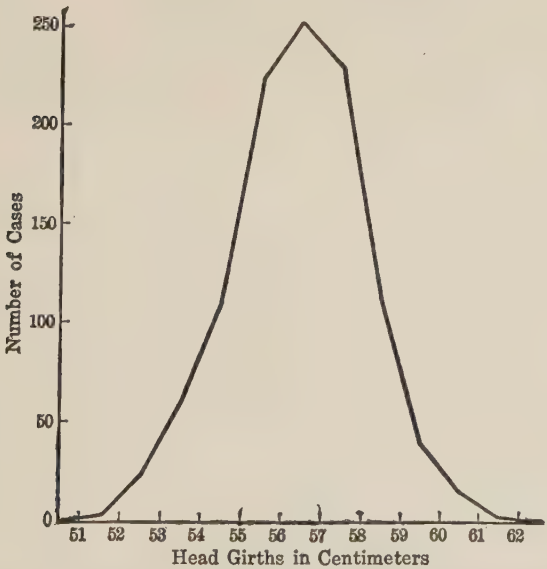


FIGURE 46. Distribution of the head girth of 1,071 boys, 16-19 years of age. (From Starch, *op. cit.,* p. 31.)

Better pictures of the general features of individual variations are secured by taking larger numbers of indi-

viduals, preferably those of about the same age. In Figures 44, 45, and 46 are given surfaces of frequency for different traits. The curves are very similar. People are not divided sharply into groups of tall, medium and short, of moral and immoral, or of bright, average and dull. On the contrary they form a continuous series, the divisions of which merge with one another. That

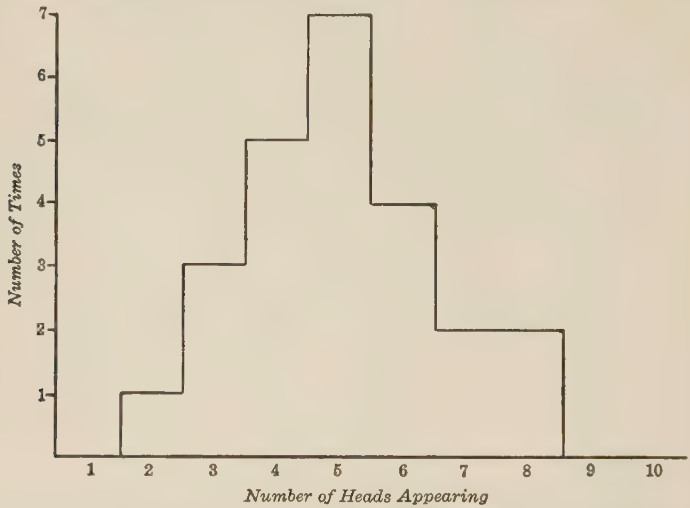


FIGURE 47. Distribution of the number of "heads" appearing in 24 throws of 10 pennies. Compare this figure, obtained by chance, with the distributions of 24 pupils shown in Figure 40.

there are steps in the series shown is due, not to the existence of such divisions in nature, but to the coarseness of the measures.

The Normal Curve of Distribution

By first examining Figures 42 and 43 and later Figures 44, 45, and 46 it will be noticed that the surface of frequency is very irregular in the former, in which small numbers of individuals are represented, and much more smooth in the latter, which embrace larger numbers.

What would be the shape of the frequency surface if an infinite or, let us say, 100,000,000 cases were included? This, of course, has never been determined but there is good reason to believe that such a surface could be predicted on the basis of the data now at hand and that it would be essentially equivalent to the theoretical distribution of chance events. If ten pennies, placed in a box, are shaken up, dumped out and the number of heads counted and recorded, and the same procedure repeated,

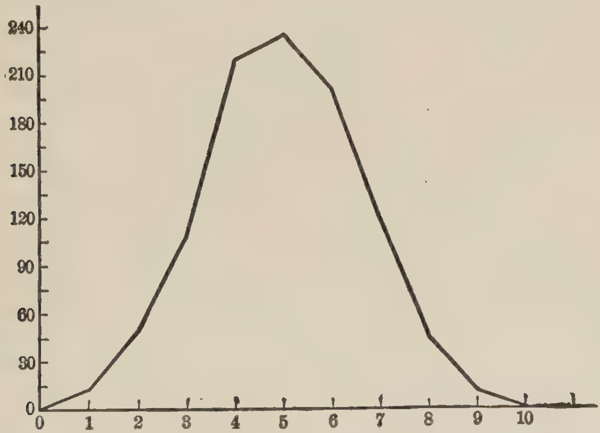


FIGURE 48. Distribution of the number of "heads" appearing in 1,000 tosses of 10 pennies. Compare with Figures 45 and 46. (From Starch, p. 32.)

we get a table of distribution of the number of heads appearing. The results of twenty-four actual throws are shown in Figure 47. This figure affords an interesting comparison with Figure 40, based on the records of twenty-four pupils in an arithmetic test. Both curves show continuous variation, a clustering about the middle and about equal irregularities of profile. For ten pennies tossed 1000 times, the distributions of heads is shown in Figure 48. Compare this curve with those of Figures

45 and 46, which were based upon measurements of about 1000 people. They are quite similar, and all are more smooth and symmetrical than the curves based on the smaller number of cases. Mathematicians without actually having tossed an infinite number of pennies have computed what the distribution would be. It is given in Figure 49 and is known by various names, most commonly the *theoretical probability curve* (*or surface*), or the *normal curve of distribution*, or the *curve of chance*. Since the surfaces of distribution for human traits paral-

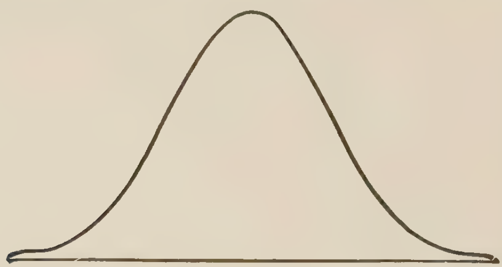


FIGURE 49. The theoretical probability curve. (From Starch, p. 33.)

lel closely the distributions of chance events in smaller numbers, it seems safe to assume that an infinite number of measurements of people of a given age selected at random would produce a curve identical with the theoretical probability curve, which portrays the outcome of an infinite number of tossings of pennies, or other chance events.

By a chance occurrence is meant not a happening without a cause, but an event determined by a large number of independent causes. To account for each penny's position, heads or tails, would require knowledge of a very large number of events happening in the box, in the air and on the table during the process of shaking and tossing. The position of each penny, nevertheless, is determined by definite causes, not by miracles.

The Causes of Individual Differences

The implication of the preceding paragraph is that the differences among individuals in any given trait are due to the large number of causal factors which operate independently. To account for the position in the group of a particular individual it would be necessary to ascertain a great many different determining factors, and to discover in what way and to what degree each had exercised its effect.

Individual differences spring from causes that may be considered under two broad headings: (1) the contributions of heredity or native endowment, and (2) the contributions of environment, that is, of the physical, and social surroundings, of education and experience.

The inherited determiners of a human trait are numerous. If one's height, for example, could be measured in hundredths of an inch, we would find the total determined in part by the thickness of the scalp, the thickness of the top layer of the skull, the vertical length of the head, the length of many vertebra in the neck and back, the thickness of cartilages between them and so on through a series of anatomical traits until the soles of the feet are reached. Each of these traits may be inherited more or less completely independently of the others. The character of growth, too, may depend upon the inherited capacity of various glands which affect digestion, assimilation and distribution of materials, upon inherited dispositions to resist disease, fatigue and undernourishment. The number of inherited traits which may to some extent determine an individual's height at any time is probably legion. To disentangle and weigh them is a task which has been barely begun. Doubtless many factors have not as yet been discovered at all and of those

which have been identified the specific effects are but roughly known.

All that is inherited, strictly speaking, is inherent in the germ cells from which the individual develops. But each character in the germ cell, whose development may exercise effects on many traits, is determined in part by various influences. In part, it is determined by the individual's sex, in part of race, by particular ancestors from the parents back through unnumbered generations. In the case of height, men are on the average taller than women, some races are taller than others, and for members of the same sex and race, some families are taller than others. Each and every one of our ancestors contributes in some degree to the amount of any traits we possess. The eminent Sir Francis Galton found that of one's native endowment, on the average one-half is contributed by one's parents, one-fourth by the four grandparents, one-eighth by the sixteen great-grandparents, one-sixteenth by the sixty-four great-great-grandparents and so on back. What one's status in a particular trait will be, insofar as it is due to heredity, then, will depend upon a large number of independent causes. All of the factors which conspired to bring about all of the marriages in one's whole ancestral history must be included among the *causes* of one's status in traits which are to some degree inherited.

The environment also provides a large number of influences which may affect human traits favorably or unfavorably in various degrees. Accidents, deprivations and disease; foods, poisons and stimulants; habits, good and bad; home conditions, school conditions, companions, teachers, books, religion, social institutions, customs, incentives, punishments, and other conditions insofar as they are potent and insofar as they differ from person to

person, may cause, in some measure, the differences among individuals. How great the influence of each environmental factor is, both absolutely and in proportion to the influence of heredity, is an important but complex question that must be answered specifically for each human trait—height, strength, ability to add, spell, sing or judge poetry. Some of these questions will receive consideration in the following chapters. For the present, our interest lies in the fact that the position of an individual in the group depends upon a very large number of causal influences, many of which are unrelated.

The status of an individual, in a group, then, like the outcome of the toss of pennies or dice, is the result of many independent causes. The distribution of human abilities is, as a result, similar to the distribution of the arrangements of dice or pennies. In both cases, though the distributions are generally spoken of as due to *chance*, they are not without adequate causes, but are the results of many independent causes. And to the extent that human traits have been measured, the distributions of unselected individuals approximates fairly closely the curve of chance.

Properties of the Probability Surface

The fact that the distribution of human abilities approximates the probability surface so closely is of great importance for the technique of mental measurements. The theoretical surface has a number of mathematical properties which have been directly or indirectly utilized. Most of these are too technical for description here; only a few samples will be described.

If we take the theoretical curve (Figure 49), cut off from the tips of each end of the figure a small area such that 99.63 per cent. of the whole area remains, and divide

the base line into five equal parts, between which vertical lines are erected, the areas (as shown in Figure 50) will

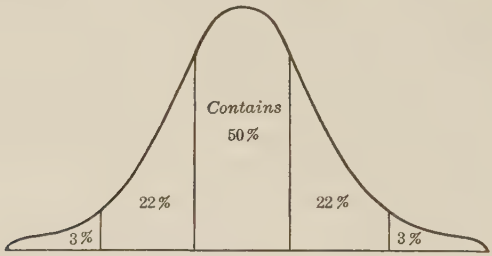


FIGURE 50. The base line of the theoretical probability curve has been divided into five equal parts and vertical lines have been erected at the dividing points giving five areas. The middle area includes 50 per cent of the whole population; the next areas on either side 22 per cent each, and the extreme areas 3 per cent each.

contain the following percentages of the cases (or individuals):

	AREA ON EXTREME LEFT	NEXT AREA	MIDDLE AREA	NEXT AREA	AREA ON EXTREME RIGHT
Per cent	3.	22	50	22	3

If a thousand children of the same age are measured for a mental or physical trait, it would be expected that they would fall into five groups each containing approximately the percentages of individuals given above. They will not do so exactly, for even when ten pennies are tossed a thousand times, the result is not exactly the distribution theoretically expected, but is a fairly close approximation. If the number of tosses, or children tested, is less, the divergence will generally be greater, other things being equal. But even for smaller groups, the tendency of abilities when carefully measured to take the form of the probability curve may be utilized in useful ways.

For example, the probability surface is a useful theo-

retical basis for grading pupils where accurate measures of ability are not available.

When large numbers of students of similar age and training are thoroughly tested by reliable methods, the scholastic and academic abilities are generally found to correspond rather closely to the normal curve, which suggests that the various grades should be assigned in at least roughly the proportions of 3, 22, 50, 22 and 3 per cent of the group. A sample of how grades in various subjects are distributed is disclosed in the following table which is based on the results of reports from a university:

PERCENTAGE OF STUDENTS GIVEN VARIOUS GRADES
(FROM MAX MEYER)

COURSE	HIGHEST GRADE A	NEXT B	NEXT C	LOWEST GRADE F	TOTAL NUMBER OF STUDENTS
Philosophy	55	33	10	2	623
Economics	39	37	19	5	161
German II	26	38	25	11	941
Mechanics	18	26	42	14	495
English II	9	28	35	28	1098
Chemistry III	1	11	60	28	1903

Of the students taking philosophy 55 per cent received "A's" and but 2 per cent "F's"; of those taking chemistry, 1 per cent received "A's" and 28 per cent "F's," while the proportions for other courses are distributed between these extremes. Recent work in testing more extensively the abilities of students in college departments makes it quite certain that such assignments of grades are not fairly representative of the variations in the abilities of students electing the several courses. The real achievements within each group approximate more closely the distributions found in the normal probability curve and consequently the grades should approximate those percentages more closely.

Soon after the irregularities in grading were revealed, the University of Missouri adopted a scheme of assigning marks which embraced the five divisions and percentages as given in Figure 50. The approximations to this ideal classification during one semester were as follows: Excellent, 3.9 per cent; superior, 19.7 per cent; medium, 51.0 per cent; inferior, 16.8 per cent, and failure 8.5 per cent.

The plan of grading adopted by the George Peabody College for Teachers gives the essentials of a method which embraces the important facts of individual differences without being too rigid in application.

"It is fair to assume that the average student in any undergraduate course is equal in ability to the average student in any other undergraduate course. Consequently it is fair to expect that all members of the faculty will in the long run (when they have marked 500 students, say) give approximately the same percentage of students each of five grades.

"It is also fair to assume that the calibre of classes does vary and that this is particularly true in the case of very small classes. Consequently it is fair to expect that the members of the faculty will vary considerably in the way they mark the members of particular classes.

"We expect then in the long run that the members of the faculty will all use the same standards. We also expect, on the other hand, that there will be noticeable variation in the way individual classes will be marked. In the light of these assumptions, the following rules are laid down:

"1. The quality of the student's work in a course shall be reported to the registrar by the use of the following grades: A, B, C, D and F.

"2. The grade of 'C' is designed to represent the per-

formance of the middle 50 per cent of the class. The grades of 'B' and 'D' represent work that is superior and inferior, respectively, to that of the middle group. The grade of 'A' is reserved for markedly superior work, while the grade of 'F' is designed for those who have failed and shall receive no credit for their work. Students receiving the grade of 'D' will receive but 80% of the full credit attached to the course.

"3. It is recognized that the more advanced the student the more selected is the class with which he will be grouped and the system of marking will vary proportionately.

"4. Experience has shown that in the long run the instructor will give approximately 3% of his students an 'A,' 22% of his students a 'B,' 50% a 'C,' 22% a 'D' and 3% an 'F.' [1]

Statistical Measures

With the variations among individuals in a group as great as they are, the practical worker at once encounters a difficulty in attempting a convenient form of expression for the group as a whole. Nothing less than the table or surface of distribution gives all the information, but these are too complex for mathematical treatment. Accordingly, various figures, which represent the group more or less adequately, are utilized in statistical work.

Mean and Median.—First among these are various averages, of which the *arithmetical mean* and the *median* are most commonly used. The *arithmetical mean* is obtained by adding the scores of the individuals in the group and dividing the sum by the number of individuals, a result which is popularly called the average. The *median* is obtained by counting in from either

[1] From E. K. Strong, *Introductory Psychology for Teachers,* p. 197.

extreme until the middle individual is reached, his score being the median. These averages yield rough statements of the central tendency of the group but give no information concerning the form of the distribution, whether it is compact or widely spread, whether smooth or irregular, whether symmetrical or skewed. Frequently, it is quite important to know, at least roughly, the variability or spread of the group. For example, two fourth grades might have attained, in a test in spelling, the same mean (or median) scores and yet be very different as groups, as shown in Figure 51.

In one group the range of ability is very wide, in the other narrow.

Measures of Variability.—There are many methods of expressing the variability of a group, and of these one of the simplest is the *mean deviation* from the mean

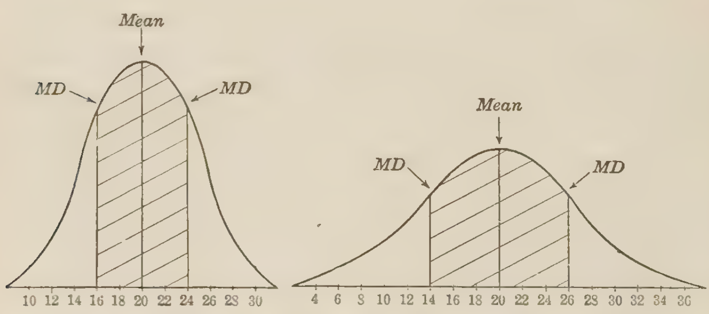


FIGURE 51. These two distributions have the same average, *i.e.*, 20. For the distribution on the left, the mean deviation is 4; for the one on the right 6. Vertical lines have been erected above the mean deviations above and below the averages. The area included between them, *i.e.*, the shaded area, includes approximately one half of the whole area.

or the *median deviation* from the median. Having found the mean (or median) of the group, the deviation of each score from it is computed, and the mean (or

median) of these deviations ascertained in the usual manner. Thus a mean of 20 with a *mean deviation (M. D.)* of 4 means a compact group as compared with a mean of 20 with an M. D. of 6. In both cases, approximately 50 per cent of the individuals will be included within the limits of the mean plus and the mean minus the mean deviation. In the first case, within the limits $20 + 4$ and $20 - 4$, i.e., between scores *24* and *16* will be included approximately half of the group; in the second case, half of the group will be included within $20 + 6$ and $20 - 6$, i.e., between *26* and *14*. These facts are illustrated graphically in Figure 51.

The Coefficient of Correlation.—In many educational and psychological investigations it is desirable to ascertain the association or correlation of two traits within a group of individuals. We may desire, for example, to discover how speed of learning and retentiveness are associated: Do the pupils who learn rapidly retain better, worse, or about the same as those who learn slowly? What we want, in this case, is a simple expression of the general association of these two abilities within a whole group. The *coefficient of correlation,* whose symbol is r, is a statistical device for securing a statement of such an association.

We shall give here no detailed account of the methods by which the coefficient of correlation is computed, but merely a simple illustration of its significance. In the series of columns below, suppose that the first numbers of each pair represent the ranks of ten different pupils, A, B, C, etc., in rate of learning. The most rapid learner is given rank 1, the next rank 2, and so on to the lowest indicated by 10. In the second column of the pair, the rank of the same pupil (A or B or C, etc.) in retentiveness is given. The *coefficient of correlation*

is a single statement of the central tendency of these relations.

ILLUSTRATING THE SIGNIFICANCE OF COEFFICIENTS OF CORRELATION (r.) OF VARIOUS MAGNITUDES

	I		II		III		IV		V	
PUPILS	RANK IN TRAIT	RANK IN TRAIT	RANK IN TRAIT	RANK IN TRAIT	RANK IN TRAIT	RANK IN TRAIT	RANK IN TRAIT	RANK IN TRAIT	RANK IN TRAIT	RANK IN TRAIT
	X	Y	X	Y	X	Y	X	Y	X	Y
A	1	1	1	3	1	3	1	5	1	10
B	2	2	2	1	2	5	2	6	2	7
C	3	3	3	2	3	7	3	2	3	8
D	4	4	4	5	4	1	4	7	4	5
E	5	5	5	6	5	8	5	8	5	9
F	6	6	6	4	6	2	6	10	6	3
G	7	7	7	8	7	6	7	1	7	1
H	8	8	8	7	8	4	8	4	8	2
I	9	9	9	10	9	10	9	9	9	4
J	10	10	10	9	10	9	10	3	10	6
	r. = + 1.00		r. = + 0.90		r. = 0.51		r. = 0.00		r. = — 0.63	

In sample I, there is a perfect positive correlation between abilities in the two traits, X and Y, which means that each pupil has in one trait the same relative ability that he has in the other. Perfect correlation which is indicated by r. = + 1.00 is extremely rare among human traits. In the second sample, the coefficient is + 0.91, a very high positive correlation which allows, however, for some shifting of positions. Pupil A, best in trait X, is third in Y; Pupil B, second in X, is first in Y, and so on. The third sample, r. = + 0.51, is a substantial but not very high positive correlation; its meaning will be best understood by examining the data of the columns. In IV, the correlation is zero, the result that is obtained when the arrangement is left entirely to chance, as would be the case, for example, if the positions under X and Y were determined by drawing the numbers from a hat. From zero to minus 1.00 is a range of negative correlations, in which the ranks in one trait are the reverse, in various degrees, of those in the other. Sample five, in which r. = — 0.63, illustrates a high negative correlation.

QUESTIONS AND EXERCISES

1. The following numbers of problems were solved by different individuals in a test of a class in arithmetic: 22, 21, 20, 19, 19, 18, 18, 17, 17, 17, 17, 16, 16, 16, 15, 15, 14, 12, 11, 9, 7. Compute the mean, median, the mean deviation from the mean, and the median deviation from the median. Are the mean and the median the same? In what kind of a distribution are they likely to differ the most?

2. Draw a curve of distribution for two classes for which the averages are the same but the mean deviation is in one case small and in the other large. Which class would you prefer to teach? Of which would you prefer to be a member?

3. Make an assignment of Grades A, B, C, D and F to the pupils whose scores in arithmetic are given in (1). What objections would you offer to the division of these pupils into five groups of marks? Suppose there were 100 pupils instead of 21?

4. Would you make the same distribution of grades for these two classes in gymnastics: (a) one which excludes only those physically defective, and (b) one which includes only those specially trained and skilled?

5. Can you think of any traits in which people are not different? Any in which there are more people at the extremes than in the middle?

6. Draw up a list of at least 30 factors, classified under two headings which contribute to one's ability to play cards.

7. Make a list of ten problems which might be solved by the use of the coefficient of correlation.

8. Place strips of paper bearing the numbers from one to ten in a box. Draw them out one at a time and record the order. Do it again and observe the resemblance between the two orders. Is it most like I, II, III, IV or V, on page 418. Try the same thing a number of times. If you did it a sufficient number of times, which order, on the average, would be most closely approximated?

9. Considering the nature of individual differences, which of the following would you consider good educational practices?

a. Having all of the pupils write to count i.e. making up, down, etc., strokes in unison.

b. Assigning the same study time to all pupils in spelling.

c. Having each child study in spelling only those words which he misses in a preliminary test.

d. Having children read in unison.

e. Giving attention only to those who are slow.

f. Insisting on keeping together the members of a class that start together.

g. Having an inflexible rule that children who have missed a month's work cannot be promoted.

h. Giving more individual instruction to bright, average or dull.

i. Giving less weight to chronological age in promotion.

j. Giving all pupils the same amount of the same subject matter.

REFERENCES

E. L. Thorndike, *Educational Psychology, Briefer Course.* Part III, and E. K. Strong, *Introductory Psychology for Teachers,* 1919, pp. 98-180.

CHAPTER XVIII

INTELLIGENCE

In the preceding chapter it was stated that all so-called human "qualities" are really complexes or composites of particular abilities existing in definite amounts ranging from zero up. This applies to the human trait intelligence, which will serve as an excellent example of both the theoretical value and the practical usefulness of the measurement of complex traits.

The fact that individuals differ in ability to learn, to adjust to novel situations, and to manage things, people, and ideas has been repeatedly observed throughout the course of recorded history. In the early stages of experimental psychology, efforts were made to measure more precisely some of the aspects of intelligence. In 1880, Ebbinghaus first succeeded in devising tests of ability to memorize various materials with sufficient accuracy to portray individual variations. Following this notable accomplishment, many types of single tests, such as the completion of sentences in which certain words were omitted, the completion of pictures, the speed of recognizing figures, words, or sentences, the cancellation of letters from specified materials, arithmetical operations, association tests, etc., were suggested as possible touchstones of general intelligence. The search for a single test, guided by the belief that intelligence was a single unitary power that might disclose itself in clean-cut fashion in a single task or situation, inevitably led to but partial success.

It remained for Alfred Binet, a distinguished French psychologist, to conceive the idea that intelligence was not a single quality or power, but a complex of abilities. The effect of this belief was a radical change in the method of approach to the problem. Conceiving intelligence to be not homogeneous but possessing many aspects, Binet began to search for many types of performances or problems in which intelligent behavior should be displayed. Believing also that intelligence was largely native, although recognizing the fact that previous experience influences the results of most psychological tests, Binet began by searching for bits of information available to children in all walks of life, and for problems, puzzles, questions, mental tasks of various types that were not likely to be encountered under ordinary home or school conditions. The information sought, then, was of the sort that every child has ample opportunity to acquire, and the problems of a type that no child was likely to have previously learned to solve.

The Binet-Simon Tests

After fifteen years of work, in part of which he was assisted by Theodore Simon, Binet published in 1908 the series of tests known as the *Binet-Simon Scale of Intelligence.* It consists of 54 individual tests which are arranged in an order of difficulty. The easiest may be passed by an average three-year-old child, the most difficult requires the ability of an average adult.

Stimulated by this successful achievement, a large number of extensions and revisions of the scale have been made in many countries. In America the work has been specially active, and among the several revisions that by Terman, known as the *Stanford Revision and Exten-*

sion of the Binet-Simon Scale, is most thorough. This scale consists of 90 tests arranged, like the original, in order of difficulty from some that should be passed by a three-year-old child to others that demand "superior adult" ability.

What the scale actually measures may be explained more readily after an examination of some of the tests. In the group for age 3 are the following tasks:

Points to the nose, eyes, mouth, hair. To pass the test, the child must succeed in 3 of the 4 tasks.

Names familiar objects—key, penny, closed knife, watch, pencil. Subject must succeed in 3 of the 5 tests.

Enumerates at least 3 objects seen in 1 of 3 pictures displayed separately.

Gives sex, i.e., boy or girl.

Gives last name.

Repeats sentence containing 6 or 7 syllables; e.g., "The dog runs after the cat."

Repeats 3 digits, one success in 3 trials.

Age 10:

Defines satisfactorily at least 30 words of a list of 50, ranged in order from easy to difficult. Words at about the 10-year level of difficulty are: bewail, priceless, disproportionate, tolerate, artless, depredation, lotus, frustrate. The hardest words in the list which are mainly too difficult for the average adult are: piscatorial, sudorific, parterre, shagreen, and complot.

Detects the "absurdity" in 4 out of 5 statements such as the following: "A man said: 'I know a road from my house to the city which is down hill all the way to the city and down hill all the way back home.'"

Copies from memory a geometrical figure previously studied for 10 seconds.

Gives satisfactory answers to 2 out of 3 questions such as the following: "What ought you to say when someone asks your opinion about a person you don't know very well?"

Must be able to say spontaneously at least 60 words—any words of which the subject can think—in a period of 3 minutes.

Among the 90 tests in the Stanford Revision of the Scale are many which measure the ability to manipulate mentally familiar facts, such as repeating digits forwards and backwards, counting backwards, visualizing changes of the hands of a clock; to reason out the solution of problems which utilize the facts of arithmetic, of physical relations, and of practical situations. In some tests, the knowledge of abstract facts and relations is demanded: e.g., in defining such words as pity, revenge, charity, envy; in giving the similarities in three things, such as wool, cotton, leather; the differences between a President and a King or between poverty and misery; in grasping the thought contained in a short paragraph; or in giving the meaning of pictures or fables. In general, the Binet test seems to include a variety of tasks on which the mental abilities described in our previous chapters on learning, the acquisition of ideas, especially abstract ideas and reasoning or problem solving, depend. Indeed, these were precisely the aims of Binet and his followers. They attempted to secure tests of various abilities to learn, especially to learn complicated and abstract facts, and also to profit by experience in a general way. They tried to secure tests that would indicate native ability to adapt oneself to new situations, to see the problem, hold it in mind, and reason out the solution. In these tasks, it is assumed that mental alertness, keenness, quickness and breadth of grasp, as well as suppleness, accuracy, and control would be involved.

Performance Tests

The Stanford-Binet is largely a verbal test; mainly the responses are made orally to questions or problems presented orally by the examiner. It cannot, therefore, be used successfully with deaf or foreign children or with

children having speech defects. For such cases, and for others who are clumsy in handling language, graded series of performance tests have been constructed along lines similar to those adopted by Binet. Of these, the most thoroughly standardized series is that of Pintner and Paterson. It includes fifteen tests, all of which require the management of concrete objects. In the "form board" test, for example, record is kept of the time

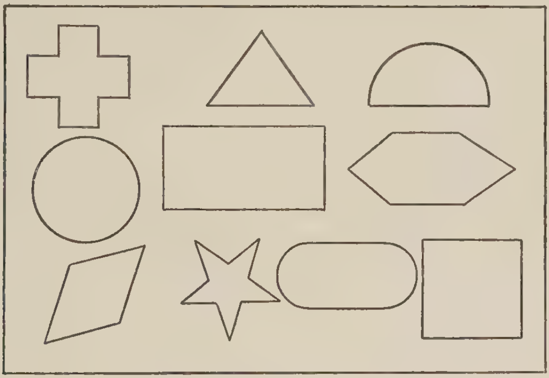


FIGURE 52. The Sequin-Goddard form board, one of the easiest, used with children or feebleminded adults. Blocks, to fit the holes shown in the above board, are placed before the subject in a prescribed arrangement. The score is based upon time required and number of errors made in fitting the blocks into the holes.

and number of false moves made by a child in placing a number of blocks of different shapes in appropriate holes in a board. The Knox cube test illustrates another type of performance. Four small cubes are placed in a row before the child while the examiner holds a fifth with which, after securing the subject's attention, he taps the others in a prescribed order, such as 1, 2, 3, 4. The child, who has been given the cube, attempts to tap the other cubes in the same order. Various orders such as 1-2-4-3, 2-1-4-3, 1-3-2-4, etc., have been carefully

standardized. A third representative performance test is a "picture completion" in which the task consists in the insertion of cut-out portions to make a picture complete and intelligible.

Group Tests

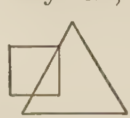
Like the Binet Scale, the Pintner-Paterson series is an instrument of precision, carefully standardized, which must be given to subjects individually by trained examiners. To meet the demands for more extensive testing, various forms of group tests which may be administered by competent people without special training have been devised.

Group tests may be divided roughly into two types, the verbal and the non-verbal, although many include both types of material. Of the verbal tests, the most familiar is the "Army Alpha," devised by a group of American psychologists and applied to more than a million men in the American Army during the Great War.

The Army Alpha test, given to recruits who could read and write, consists of 212 separate questions, exercises, or problems of eight general types, of which four are here illustrated.

The first group of tests comprised twelve tasks ranging from easy to hard, of the following type:

The examiner says: "Attention. Look at the square and triangle at 3. When I say 'Go,' make a cross in the

3. 

space which is in the triangle but not in the square, and also make a figure 1 in the space which is in the triangle and in the square.—'Go!'" (Allow not over ten seconds.)

Test 2 consists of 20 arithmetic problems.

Test 3 consists of 16 "common sense" problems. The subject is to make the best answer. The easiest and most difficult are: (1) Cats are useful animals because—they catch mice; they are gentle; they are afraid of dogs. (16) Why is it colder nearer the poles than at the equator? Because—the poles are always farther from the sun; the sunshine falls obliquely at the poles; there is more ice at the poles.

Test 4 consists of 40 pairs of words, the two words of each pair being either synonyms or antonyms. The examinee is to underline *same* or *opposite* where appropriate. The first and last pairs are:

wet—dry........................same—opposite
encomium—eulogy...............same—opposite

There are many other verbal group tests, some especially designed for elementary schools, some for high schools, some for colleges, and others for use among clerical and other occupational groups. Non-verbal group examinations have been devised to test very young children, illiterates, and others who cannot read or write words. In some of these examinations directions are conveyed orally; in others by means of pantomime. A variety of tasks are provided, such as to draw a line to indicate the shortest path through a maze, to fill in the missing part of a picture, to strike out an irrelevant part, or to complete a series of marks begun according to a fixed plan. In each type of test, problems ranging from easy to hard are provided.

The various types of tests and scales are not exactly equivalent. They do not all measure identical abilities, although there doubtless is a good deal in common among them. It will be advisable, therefore, to confine the discussion mainly to one test, the Stanford-Binet.

Mental Age and the Intelligence Quotient

The Mental Age.—To make the subject's score on an intelligence test meaningful, a standard of comparison must be provided. The method adopted by Binet, and by many others later, was to use the average performances of individuals of different ages as a standard of comparison. Binet ascertained just what the average score achieved by a group of three-year-old children, four-year-old, etc., was. Of course, in such a procedure care must be exercised to get a sufficient number of representative children for each age: not merely a few bright ones or dull ones, but all kinds, picked at random, giving a distribution of ability approximating the normal surface of frequency. When this is done, it becomes possible to state a child's achievement in terms of the age at which the child of average ability would secure the same score. This score is called the "Mental Age" or the "M.A." for short. Thus, a particular child whose achievement in the test is equivalent to the Mental Age of ten years has the general mental ability of the average ten-year-old; it matters not what the actual chronological age of the particular child may be.

The Mental Age, then, gives us a statement of the general mental ability of a subject *at the time of the test* in comparison with average children of different ages. If a ten-year-old child earns an M.A. of 10, he has *average* mental ability. If he earns an M.A. of eleven years he is obviously superior to the average; if he earns an M.A. of eight years, he is markedly inferior. The Mental Age is really a statement of a child's mental maturity at the time, and this implies, of course, that general mental ability grows or matures. There is, indeed, fairly substantial evidence that general mental

ability as measured by the Binet tests grows gradually and about as uniformly as height to a maximum or maturity which is reached about the same time, i.e., in the late teens. Terman has placed the average age of maturity at 16, although others have put the date at various points between 13.2 and 16. These are approximate statements of the average; particular individuals mature mentally at different ages as they do physically. (See Figure 54.)

The Intelligence Quotient.—For practical purposes, we want to know more than merely the amount of general mental ability at the moment; we wish to know, if possible, how rapidly the child's mental ability will develop. We desire to be able to predict growth in mental ability; to tell what it will be one, two, or more years hence. The device most commonly used for this purpose is the Intelligence Quotient, or the "I.Q." The Intelligence Quotient is obtained by dividing by the chronological age the mental age received on a test like the Stanford-Binet. For example: Pupil A has an M.A. of 10 years and a chronological age of 10 years. Divide M.A. 10 by C.A. 10, the Intelligence Quotient is 1.00; Pupil B, whose chronological age is also 10, has an M.A. of 12; 12 divided by 10 gives an I.Q. of 1.20. Pupil C, also 10 years of age, earns an M.A. of 8, which, divided by 10, gives an I.Q. of .80. Usually the decimal is disregarded; we say that A has an I.Q. of one hundred, B of one hundred twenty and C of eighty. The I.Q. is obviously a ratio—the ratio of the Mental Age to the Chronological Age.

The value of the Intelligence Quotient for purposes of prediction depends upon the fact that it is found to be—at least approximately—constant from year to year. This fact is ascertained by repeatedly testing, at inter-

vals of a year or more, the same individuals with the same tests. Thus far, the Stanford, and to some extent other revisions of the Binet Scale, are the only ones that have been tried out in this way. A number of investigations have shown that the I.Q. on a retest at an interval of a year or more varies somewhat in par-

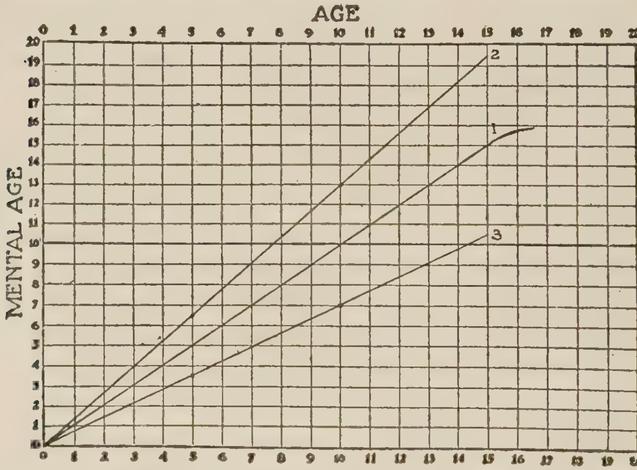


FIGURE 53. Mental growth curves as they would be if the I.Q. were constant. Number 1 is a mental growth curve as it would be if a child continued to test at 100 I.Q.; number 2 for a child continuing to test at 133 I.Q., and number 3 for a child of 67 I.Q. (From Terman's *Intelligence of School Children*, Copyright 1919, published by Houghton Mifflin Company.)

ticular cases, but on the average the change is 5 points or less. (See Figures 53 and 54.)

The Intelligence Quotient indicates, then—at least approximately—the rate of mental growth. An I.Q. of 100 means that the child probably has grown, is now growing, and will continue to grow in mental ability at the average rate. An I.Q. of 120 means a growth 20 per cent more rapid; an I.Q. of 75 means growth 25 per cent less rapid than the average. Since the I.Q. remains approximately constant from year to year, it expresses

the relative brightness or dullness of an individual. Thus, irrespective of age, an I.Q. of 100 means average mental alertness, suppleness, breadth of grasp, and capacity to learn, whereas a higher I.Q. indicates superiority in these respects and a lower I.Q. inferiority.

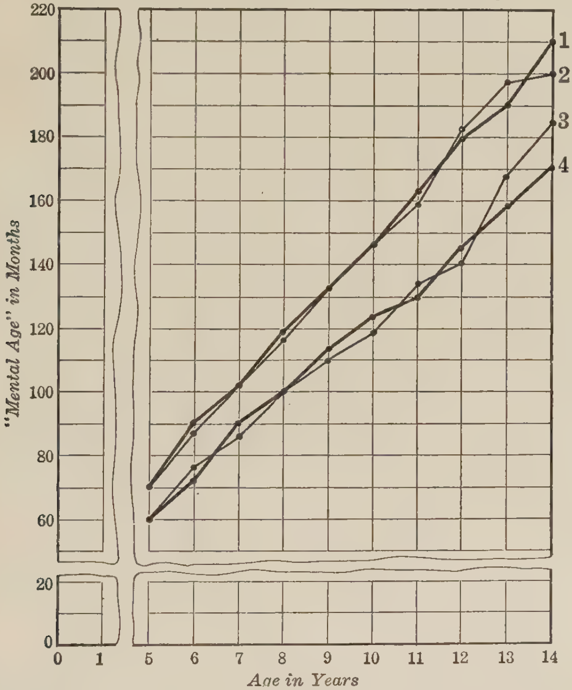


FIGURE 54. Actual mental growth curves for four children obtained by consecutive annual measurements with the Stanford-Binet scale. Number 1 is the curve for a bright boy; 2 for a bright girl; 3 for a duller boy, and 4 for a duller girl. Compute the I.Q.'s and compare results with Figure 53. (From Baldwin and Stecher, *Univ. of Iowa Studies,* Vol. II, No. 1.)

IS GENERAL INTELLIGENCE NATIVE OR ACQUIRED?

The Binet tests were devised to measure *native* mental aptitudes. What is the evidence that intellectual capacities are inherited and that they grow like height to a

maturity which was essentially predetermined by conditions in the germ cells?

The approximate constancy of the Intelligence Quotient is one line of evidence. If intelligence were essentially modifiable, the variations in experience would, of course, cause corresponding variations in I.Q. But they do not. We find, on the one hand, children who have enjoyed exceptionally good care at home and school, remaining at approximately the same low I.Q. For example: "X is the son of unusually intelligent and well-educated parents. The home is everything one would expect of people of scholarly pursuits and cultivated tastes. . . . When brought for examination X was eight years old. He had twice attempted school work, but could accomplish nothing and was withdrawn. The Binet tests gave an I.Q. of approximately 75, that is, the retardation amounted to about two years. The child was examined again three years later. At that time, after attending school two years, he had recently completed the first grade. This time the I.Q. was 73." [1]

That school or other formal educational training does not appreciably increase the I.Q. is shown by such cases as the following:

"Walter and Frank have been under observation for several years. Until the ages of five and seven years, they lived in an exceptionally poor home. . . . Both of the parents died within a year, and the boys were adopted by a woman of decidedly more than average ability, who treated them as her own sons. At the time of adoption, one tested at 73 and the other at 82. Four years later, the I.Q.'s were 70 and 77." [2]

[1] TERMAN, *Measurement of Intelligence*, p. 117.
[2] TERMAN, *Intelligence of School Children*, p. 14.

The writer secured the results of Binet tests from a group of 70 school children (Grades 3 to 6 inclusive) whose achievements in all of the representative school subjects were also carefully measured. During a period embracing nearly two school years, unusually intensive work in reading, spelling and arithmetic had been done with many of the pupils who were backward in these subjects. The improvements in scholastic attainments varied greatly among the subjects who were, near the end of the period, retested with the Binet scale. Most of the pupils showed some change in I.Q., the greatest gain being 18 points, from which the changes varied to a loss of 12 points, with an average change of about 6 points. The important question was whether great gains in I.Q. were made by those whose advance in educational achievements had been greatest and whether losses in I.Q. occurred mainly among those who had made the least amount of scholastic progress. There was no association between the two tendencies; the correlation was zero. An increase in I.Q. was found as frequently among those whose achievements had been small or average, as among those whose progress had been great. Those whose educational progress had been great gained in I.Q. no more frequently than those whose gains were small or average.

From these instances, it appears that while the tests are still imperfect, they disclose quite clearly the fact that there are innate mental capacities, the growth of which is not greatly accelerated or retarded by intensive school training. The general tendency of the I.Q. to remain constant implies that, in the main, individuals are born and tend to remain at a level which is relatively low, average, or high. This is the rule, although there are exceptions.

High, low, and average mental ability tends to run in families in much the same way as height, eye color, and other physical features. The inheritance of intelligence is most vividly illustrated in the lineage of extreme cases, of which the "Kallikak" family is a notorious example. Martin Kallikak, a youthful soldier in the American revolution, met a feeble-minded girl who bore him a son of low mentality. In 1912 there were four hundred and eighty known direct descendants of this union. Of these, one hundred and forty-three were of such low mentality as to be classified as feeble-minded, and most of the others were of relatively low mental ability. In addition, thirty-three of the latter were sexually immoral, thirty-six of illegitimate birth, and twenty-four confirmed alcoholics.

Contrast the dark picture of the Kallikaks with the accomplishments of the Edwards family. Of Jonathan Edwards, born in 1703, there were, in 1900, 1394 identified descendants, of whom thirteen were college presidents, sixty-five college professors, sixty physicians, one hundred clergymen, seventy-five army or navy officers, sixty prominent authors, one hundred lawyers, thirty judges, eighty prominent public officials, and a great many successful bankers, business men, landowners, etc. None was known to be of feeble mentality, and none was known to have committed a crime, while many achieved great eminence in their profession.

More reliable evidence of the inheritance of mental ability is obtained by precise measurements of relatives. Thorndike, using several mental tests which, taken together, gave a fair measure of intelligence, found that twins are very similar in ability, and that siblings (children of the same parents) are also similar, but considerably less so than twins. If similarity in training

is the cause of similarity in intelligence, siblings should show nearly as great a resemblance as twins. They show, however, only about half as great a resemblance. Furthermore, if similar training accounts for similar intelligence, those twins subjected to the same home and school environment should become more and more alike as they grow older. But they do not; the resemblance of twins 9 to 11 years old is quite as great as those 12 to 14 years.

The Significance of General Intelligence

The implication of the preceding section is that general intelligence, provisionally defined as a composite measure of abilities to learn, to grasp broad and subtle facts with alertness and accuracy, to exercise mental control, and display flexibility and sagacity in seeking the solution of problem-situations, is native—that is, it develops fairly steadily like height, reaches a maturity at some time in the teens, and sets for each individual a limit of achievement. These implications must be further tested.

We shall first indicate the form of distribution of the Intelligence Quotients, and then proceed to study the significance of the several levels. Generalizing from the measurements of groups of representative children, the distribution of intelligence would probably be about as given in the following table:

I.Q.	below 70,	1%
I.Q.	70-79,	5%
I.Q.	80-89,	14%
I.Q.	90-99,	30%
I.Q.	100-109,	30%
I.Q.	110-119,	14%
I.Q.	120-129,	5%
I.Q.	over 130,	1%

Intelligence and Scholastic Achievement

Inferior Intelligence.—Intelligence Quotients of 20 or less are found infrequently. Persons with I.Q.'s in this range are "idiots," essentially incapable of learning. Individuals with I.Q.'s from 20 or 25 to 50 or so are ordinarily called "imbeciles" and all within this range are capable of but meagre learning and adaptability. In the range from 50 to 70 I.Q. are found various degrees of "feeble-mindedness," which grade quite imperceptibly into the less, but nevertheless seriously, dull individuals above. Throughout this enormous range, from approximately 0 to 70 I.Q., there is absolutely no doubt about the innate limitations upon the acquisition of complex mental functions, and the rate of acquisition where learning is possible at all. It is almost invariably futile to attempt to teach children of I.Q.'s less than 50 to read, spell, or do arithmetic. Genuine comprehension in reading or arithmetic can seldom be achieved even by those whose I.Q.'s fall between 50 and 60, and the little they do learn must be the result of arduous and prolonged application.

In the average case, an I.Q. of 75 is considered about the minimum essential for appreciable achievement in school work, but many with that degree of intelligence fail almost entirely and, at best, progress is slow and soon halted. The average case can scarcely succeed beyond the fifth grade. In the schools most of the pupils recognized by teachers as "very dull" and "very slow" will be found to have I.Q.'s between 70 and 85. Most of these children are retarded in their school progress. Children with I.Q.'s of 80 to 85 drop out early in considerable numbers, but many struggle along to finish the eighth grade 1, 2, 3, 4, or more years retarded. It is

found that most of those who persist are promoted more rapidly than their achievements warrant, mainly because they are bigger and older.

The average child with an I.Q. of 90 is usually delayed a half or a full year in completing the eight grades. The average child with an I.Q. of 95 is quite likely to finish on time. Burt found that among London children those with I.Q.s from 85 to 95 are the ones from the whole range of intelligence with which the school achieves the most in proportion to their innate ability. "There is discernible an effort, and an effort by no means sterile, to coax and coach these milder dullards to a grade more closely fitted to their actual age." But Burt, like many others, found that despite coaxing and coaching, these children seldom equal the children of average endowment (i.e., with I.Q. of 100). That they have difficulty in keeping up the pace set by the school is here implied, and that most of them at the end of Grade 8 have about reached their limit is indicated in a study by Proctor, who found that in the first year of high school 70 per cent of those with I.Q.s of 95 or less failed in more than half of their studies.

Average Intelligence.—Children of average intelligence—those whose I.Q.s cluster closely about 100—set the pace in the grades. Examining the records of two hundred pupils, whose I.Q.s range from 95 to 105, Terman found that aside from retardations clearly due to loss of schooling through illness or other causes, nearly all had made regular progress. The range 95 to 105 I.Q. includes about thirty-three per cent of the general population and probably about forty per cent of the population of the grammar schools.

Superior Intelligence.—The total number of children above 105 is about the same as that below 95; namely,

about thirty-three per cent. The former exceed the average in intelligence as much as the latter fall short of it. Since the I.Q.s are really ratios of mental growth, it is held by many that the rate of progress through school should show similar ratios. That is, if the child with an I.Q. of 100 progresses at a given rate, one with an I.Q. of 75 should progress seventy-five per cent as fast; one with an I.Q. of 125 should progress twenty-five per cent more rapidly than the average; and so on. But just as the children between 85 and 95 are coaxed and coached along because they need it, and are promoted undeservedly to keep the age group intact, those above 105 are given less attention, because it is seldom needed, and are retained in the group with the same chronological age. Extra promotions of children of 100 to 110 I.Q. are therefore not numerous. The child of 113 should be able, some maintain, to complete eight grades in seven years; 125 I.Q. in six; 138 in five; and 150 in four. That these are entirely justifiable expectations is not as yet clearly demonstrated, although there is no doubt that children of higher I.Q. are scholastically more proficient.

Of fifty-four children between 120 and 140 I.Q.s studied by Terman, 12½ per cent were advanced in the grades two years; 54 per cent were advanced one year; 28 per cent were making average progress; and 5½ per cent were actually retarded one year. Of a group of forty-seven children with a medium I. Q. of 145, Terman found none retarded; 8.5 per cent at the grade corresponding to their age; 29.8 per cent advanced one year; 29.8 per cent advanced two years; 19.2 per cent three years; and 12.8 per cent four years. This is substantial evidence that the children of better than average I. Q. do exceed the average rate of learning such subjects as

are taught in school, and that, on the whole, the higher the I. Q., the more rapid the progress.

Intelligence and Success in High School.—With regard to the limits of progress in high schools, much depends upon the standards of the school. I.Q.s of 100 do complete the high schools, but in just what proportions is not known. Among first-year students in Palo Alto High School, the relation between achievement and I. Q. is shown in these figures collected by Proctor and Terman:

1 SCHOOL MARKS	2 AVERAGE I.Q.	3 NUMBER OF PUPILS
50-59	85	12
60-69	100	16
70-79	107	56
80-89	110	24
90-99	123	4

On the average, pupils with higher I.Q.'s earn the higher grades.

Comparison of columns 2 and 3 gives an idea of the personnel of the first-year class in a first-class high school. Approximately two-thirds of the group are 100 or above, half are 105 or above, and a quarter are 117 or above in I. Q. At the end of the first year, of thirteen who dropped out of school, ten were below the median I. Q. (105) and of these, seven had failed in more than half of their subjects.

Intelligence and Success in College.—The minimum I. Q. required for successful work in college is not definitely known, since none of the Binet revisions contains tests sufficiently difficult to measure high adult intelligence.

In college, however, as in the lower schools, the correlation between intelligence and quality of work is positive and fairly high. For example, in Columbia College, the higher the rating on the Thorndike Intelligence test, the

better the achievement in the classroom, on the average. In the accompanying table are given, in the first column, ranges of scores by tens on the Thorndike test (these are not I. Q.s but raw test scores) and in the second column the percentages of students who received average classroom grades of "B" or better during a semester. To represent each range—i.e., 60 to 70, etc.—fifty students were selected at random.

RANGE OF SCORES ON THORNDIKE TEST	PER CENT OF 50 MEN IN EACH RANGE WHO AVERAGED "B" OR BETTER
60- 70	4
70- 80	8
80- 90	14
90-100	30
100-120	50

Exceptionally High Intelligence.—What a child of very high I. Q. can do, under favorable educational opportunities, is illustrated by a case reported by L. S. Hollingworth: E . . . , in 1916, was a boy 8 years and 4 months of age, with an I. Q. of 187, and in Grade 8.

"In addition to his regular school work the child has covered the following special work in language and mathematics, either with a tutor or with his mother: Geometry, algebra, as far as equations; Latin, partial knowledge of the four declensions, (he has been taught by the direct, informal method, and reads easy Latin); Greek—worked out the alphabet for himself from an astronomical chart, between the ages of five and six years; French, equal to about two years in the ordinary school; German, ordinary conversation; Spanish, attended class with his mother,—reads and understands; Italian, reading knowledge, simple conversation; Portuguese, asked his mother to take this language at the Columbia summer school because he could not be registered himself; Hebrew, a beginning; Anglo-Saxon, a beginning. In astronomy he has worked out all the constellations from

MacCready, and displays a very great interest in this subject. One evening this winter he noticed a new planet near the Twins. He said it was Saturn, but his mother thought it was Mars. E . . . went home, worked the position out from the chart, and found it to be Saturn. He has a great interest in nature, wherever found, and is already able to use Apgar intelligently. His writing is not equal to his other accomplishments. He is very slow at it and for this reason dictates most of his 'home work' to a stenographer. History is his chief and absorbing interest among school subjects."

At the age of 9 E . . . had completed the work of Grade 9; at 11 years and 10 months, graduated from high school; and at the age of 13 had completed three semesters of work in Columbia College. In capacity for scholastic achievement, this boy greatly surpasses the average.

In sum, there is impressive evidence that general intelligence as measured by the Stanford-Binet tests indicates with a faithfulness that makes it extremely useful practically the rate at which children learn *most school functions.* It sets a limit to the kind, difficulty, or complexity of mental functions that can be acquired, and it sets a limit to the rate and permanence with which acquisition, within these limits, may go on. Algebra and geometry as now taught, for example, are beyond the mental capacities of many, and among those who find these functions within the limits of their capacity, individual differences in the rate, comprehensiveness, and permanence of learning will be found, due to differences in endowment.

Intelligence and Particular School Subjects

While the results of the Binet tests indicate very well the probable achievements in school work as a whole, they

are not equally symptomatic of capacities in the particular subjects. The degree to which the tests indicate capacity in the several school functions is suggested by the coefficients of correlation between test scores and actual attainments. Taking as groups children in the same grades, Burt found the following average correlations:

CORRELATION BETWEEN	
Intelligence and composition	.63
Intelligence and reading	.54
Intelligence and arithmetic (problems)	.55
Intelligence and spelling	.52
Intelligence and writing	.21
Intelligence and handwork	.18
Intelligence and drawing	.15

These correlations show that the Binet tests do not measure native capacity in all scholastic lines equally well. The tests correspond quite closely to the children's ability in the linguistic and abstract subjects—composition, reading, spelling, arithmetic. Children with high I. Q.s are generally superior to those of lower I. Q.s in these subjects, but they are not markedly superior in writing, handwork, and drawing, that is, in mechanical and motor abilities.

It should be noted, however, that the correlations between the intelligence tests and the latter functions, though low, are nevertheless positive. In the long run, individuals with high Binet scores will excel the others even in these functions. These facts may be displayed more clearly by a comparison of a group of 14-year-old children whose I. Q.s average, approximately, 58 with another group of the same age whose I. Q.s average about 100, as shown in the accompanying table, which gives percentages of achievement of the average group attained by the duller.

Showing the Percentage of the Ability of the Group with an Average I.Q. of 100 Possessed by a Group with an Average I.Q. of 58

Spelling	46.7
Reading, comprehension	48.9
Composition, quality	50.3
Arithmetic, written problems	51.7
Writing, quality	62.1
Drawing	64.9
Handwork	69.7

In writing, the children of very low I. Q. do only about 62 per cent. as well as those of average intelligence of the same age; in drawing about 65 per cent., and in handwork about 70 per cent. as well. These are average results; the overlapping of very dull and average children in motor and mechanical skills is considerable.

Intelligence and Vocational Success

Intelligence, as measured by the Binet tests, shows substantial correlations with general scholastic success, especially in such subjects which demand linguistic ability and the acquisition and manipulation of abstract ideas. Whether the same relations hold between intelligence and success in vocations under the more complex situations of life, is a matter worthy of investigation.

Unfortunately, the number of adults that have been measured by the Stanford test is limited. The test was not designed for adults. The Army Alpha, which was devised for this purpose, should yield results that are suggestive at least. The average scores on the Army Alpha test obtained by various occupational groups are shown in the table on the following page.

SCORES[1]	OCCUPATIONS
40 to 49	—Farmer, laborer, general miner and teamster.
50 to 58	—Hostler, horse-shoer, tailor, barber, general carpenter, painter, truck chauffeur, baker, cook, concrete or cement worker, mine drill runner, bricklayer, cobbler.
60 to 69	—General machinist, lathe hand, general blacksmith, brakeman, locomotive fireman, auto chauffeur, telegraph and telephone lineman, butcher, bridge carpenter, railroad conductor, railroad shop mechanic, locomotive engineer, laundryman, plumber, auto repairman, pipe fitter, auto engine mechanic, tool and gauge maker, stock checker, detective and policeman, toolroom expert, gunsmith, marine engineman, hand riveter, telephone operator.
70 to 79	—Truckmaster, farrier and veterinarian, receiving clerk, shipping clerk, stockkeeper.
80 to 89	—General electrician, telegrapher, band musician, concrete construction foreman, photographer.
90 to 99	—Railroad clerk, general clerk, filing clerk.
100 to 109	—Bookkeeper, army nurse, mechanical engineer.
110 to 119	—Mechanical draughtsman, accountant, civil engineer, Y. M. C. A. secretaries, medical officers.
Over 120	—Army chaplains, engineering officers.

When comparisons of radically different vocations are made, there is at once perceptible a tendency for vocations which require facility in dealing with words and symbols to stand higher than those which require aptitude for manipulating things and mechanisms. The clerical workers in general excel those engaged in mechanical occupations. The tests appear to have a verbal and linguistic bias; to favor those skilled in handling words and symbolic concepts as contrasted with those proficient in motor and mechanical abilities, in vocational life as they did in the school.

Further examination of the data, however, will disclose the fact that the intelligence test measures abilities which

[1] These are raw scores, not to be confused with I.Q.s.

possess a wider significance. Making comparison within a similar type of occupation, the more skilled workers appear to stand higher on the intelligence scale than the less expert. The mechanical engineer and draughtsmen are above 110, the general electrician and construction foreman score about 85, the workers on more specific tasks, such as automobile repairman, plumber, tool maker, bridge carpenter, auto chauffeur, etc., are below 70, while the unskilled laborers are at the bottom of the list. Among the several types of clerical workers, a similar correlation between intelligence and occupational levels exists. The chaplains surpass the Y. M. C. A. secretaries, the accountant the bookkeeper, the medical officers the army nurses. Thus within similar occupational lines, general intelligence is associated with levels of proficiency.

It is significant that the members of the professional classes nearly always rank high in intelligence tests. In this connection, the average Army Alpha ratings of the students in various departments of a representative state university will afford interesting comparison with those of the occupational groups, just given.

Median Alpha Scores of Various Departments in Ohio State University (5,950 Students)

DEPARTMENT	SCORE
Liberal Arts	147
Medicine	142
Law	142
Engineering	141
Agriculture	133
Pharmacy	125
Dental College	115
Veterinary College	112

The medians of the students in most of these professional courses are well above all of the army occupational groups except the professional classes. A relatively high

degree of general intelligence of this type is probably essential to success in the ministry, law, editorial work, medicine, banking, engineering, and other vocations for which college training is required.

A survey of the army occupational groups shows in general that those which stand high have probably had, on the whole, a greater amount of "schooling" than those standing low. The additional fact that college students do so well suggests the possibility that success in the Alpha test is largely determined by the amount of scholastic training. While this test probably is influenced more than the Binet Scales by education, it measures native capacity in the main, as the following sample data imply.

THE AVERAGE ALPHA SCORE, AVERAGE AMOUNT OF PREVIOUS SCHOOLING, AND AVERAGE SCHOLARSHIP RATINGS OF 42 STUDENTS OF THE U. S. VETERANS BUREAU AT STANFORD UNIVERSITY

NUMBER OF STUDENTS	ALPHA SCORE	AVERAGE PREVIOUS SCHOOLING	SCHOLARSHIP RATING
3	75-104	9 grades	0.0 (all total failures)
6	105-119	10.2 grades	0.50
6	120-134	10.6	1.07
13	135-154	10.7	1.35
13	155-212	9.8	1.93

(The scholarship rating was obtained by giving three credits for each "hour" of A work, 2 for B, 1 for C, and 0 for D or F. These credits were added, and the sum divided by the number of hours of work attempted.) (From Proctor.)

The previous education of these groups differed very much less than the test scores. High test scores, rather than the advantages of previous schooling, seemed to foretell most accurately the achievements in the college courses. For example, one of the best records was made by a man who had the least previous education (5th grade) but a high Alpha score. Of four students who had previously done only the work of grade eight, two

whose Alpha scores were very low failed in all of their college subjects; a third whose Alpha score was in the second group earned a scholarship rating of 1.00; and the fourth, in the highest Alpha group, received a scholarship rating of 2.13, which was higher than that earned by any other student, without regard to previous education, whose Alpha score was below 155, i.e., below the highest Alpha group.

Intelligence and Social Adaptability and Leadership

Between intelligence scores and general school success, there is a substantial correlation; between intelligence and vocational success a marked, but as yet not thoroughly appraised, association. What is the correlation of abstract intelligence with social adaptability and leadership, with ability to get along with and manage people?

The use of the tests in the Army provided material that suggests a fair correlation between fitness for managing and leading men and intelligence ratings. The students of the Officers Training Schools who succeeded in earning commissions were on the average of higher intelligence, according to the tests, than those who failed. Among non-commissioned recruits in the cantonments, the correlations of fitness for advancement as judged by officers and intelligence score was fairly high (.40 to .60). Finally, the average intelligence of seasoned troops corresponded fairly closely with military rank. In one group, which included approximately 30,000 men, the privates obtained an average Alpha score of approximately 73, corporals 95, sergeants 107, and commissioned officers 139. The overlapping of the intelligence scores of one rank upon others was great, however.

The relation between intelligence and social sagacity, adaptability and leadership has been indicated by studies of children. Among 150 first-grade pupils, intelligence correlated with various traits judged by teachers as shown in the accompanying table:

Correlation of Stanford Binet I. Q. and Traits as Indicated (From Terman after Dickson)

Trait	Correlation with I.Q.
Social adaptability	.47
Leadership	.44
Self-expression (speech)	.37
Popularity among fellows.........	.34

These results show much the same general relations as those obtained on adults in the army. All lead to the conclusion that the intelligence tests correlate in some degree, but by no means perfectly, with the capacities required in understanding, getting on with, and managing other human beings.

Intelligence and Moral Adjustments

Fine gradations of moral adjustments are difficult to obtain. We may seek for some evidence in the studies of the relation of intelligence to delinquency and crime. Of this association, it is impossible to make a precise statement, so diverse are the findings of different investigators. For example, one authority asserts that "probably 80 per cent of the children of the Juvenile Courts in Manhattan and Bronx are feeble-minded"; another, that of the cases in the Newark Detention Home, New Jersey, 66 per cent are "distinctly feeble-minded"; another that "one-third of our delinquent children are feeble-minded"; another that about 8 per cent are. For these discrepancies there are several explanations of which two are important: (1)

The diagnosis of "feeble-mindedness" has not in all of the studies been based on tests of intelligence alone; and even when it has been, the line of demarcation between "normal" and "feeble-minded" is drawn at different levels; and (2) the studies are usually based on different institutions which are devoted to quite diverse types of delinquency or crime.

Of the many individual studies, one made by Burt will be considered because it is probably fairly typical and because of the care with which both intelligence and other abilities were measured. The group comprises 107 juvenile delinquents, ages six to fifteen, whose misdemeanors include theft, begging, truancy, assault, sexual offences, damage to property, and general incorrigibility. The average chronological age of the entire group was 13.2 years, the average mental age 11.3, thus giving an average retardation of two years in mental age or an average I.Q. of 85.6. Analyzing the distribution further, it is found that 7 per cent might be classified as "feeble-minded"; 20 per cent as very dull; 50 per cent as less dull but below average; 25 per cent as about average; and only 2 per cent as slightly above average. Supernormal intelligence among children is not incompatible with delinquency; but delinquents of high intelligence are rare. While the proportion of feeble-mindedness in the delinquent group is not great, it is at least five times as great as the proportion of feeble-mindedness in the total population. The more significant fact, however, is that the delinquent group, as a whole, is a dull group; only 2 per cent are above the average.

In Burt's study, the educational attainments of the delinquent children were appraised by objective tests with results most significant. The retardation in school attainments is twice as great as the retardation in men-

tality; namely, the equivalent of nearly four years. With a chronological age of 13.2, the educational achievements of these children were those of average children of 9.5 years. Not a child was above the average of his life age in school attainment; only 5 per cent were approximately equal to it; a fifth were slightly below, and three-quarters were retarded by 30 per cent or more.

Typically, then, the delinquent child is a dull child but not all dull children are delinquent. Social and moral deficiency is explained by dullness plus something else; plus other traits which typically result also in relatively marked backwardness in scholastic achievement. To a considerable extent, the other traits are probably emotional and temperamental deficiencies or nervous instability; traits previously considered in Chapters VIII and IX—although irregular school attendance, physical defects or deficiencies, unfavorable home, school, or street influences, disease, and other factors play rôles of some importance. The compelling drives of dominant instincts, the incapacity for sustained effort, fickleness of interest, or the disrupting effects of unstable but impulsive emotions when combined with dullness of mind provide an organism readily susceptible to misdemeanor and crime.

Conclusions

The results of tests, such as the Binet or the Army Alpha, together with studies of the inheritance of mental traits lead to the assumption of general intelligence. By intelligence is meant a group or composite of native capacities for learning along the lines that require mental operations with verbal, symbolic, and abstract materials. In these fields, the more intelligent person learns more rapidly, displays greater mental keenness, accuracy, and

control in meeting new problem-situations, and is capable of ascending to higher levels of achievement than the less intelligent person.

The intelligence tests do not measure all types of capacities to learn, but those which are tested are of great importance. Upon such capacities mainly depends achievement in school and colleges and success in many vocations. Social adaptability, proficiency in managing people, and effectiveness of moral adjustments are also associated to an appreciable degree with this type of intelligence. The correlation of intelligence with ability to acquire various mechanical and motor skills—writing, drawing, painting, athletics, and various mechanical trades—is positive but low.

QUESTIONS AND EXERCISES

1. To what extent are the factors which are involved in reasoning also involved in taking intelligence tests? Do you think the reasoning tests given in Chapter 14 would make good tests of general intelligence?

2. A boy of 10 with an I.Q. of 140 would have what mental age? A boy of 14 with an I.Q. of 100? In what respects would these two boys resemble each other or an adult with an M.A. of 14? In what respects would the three be very unlike?

3. If you were selecting children to form a homogeneous grade, what measure would you use, the M.A. or the I.Q.? Why?

4. What arguments or evidence can you offer to support the contention that intelligence tests measure the results of school training mainly? How might the facts be determined experimentally?

5. Carefully distinguish between intellectual capacity and achievement.

6. What factors other than intelligence may contribute to success in life?

7. Do you suppose the methods of teaching which are best for I.Q.'s of 130 and over are best for those of 100? For those of 70?

8. Comment on this statement, "it may be of greater value to

society to discover a single gifted child and aid in his proper development than to train a thousand dullards to the limit of their educability."

9. How would you explain the fact that children of superior intelligence when graded with those of the same age occasionally become mischievous, lazy or bored with school work?

10. Is it conceivable that a person could have too much intelligence to be successful or happy in certain vocations? Illustrate.

11. If children were to be grouped according to Mental Age, what difficulties of administration would be encountered? What, if any, difficulties in social adjustments?

12. Have you observed any cases of irregular educational development, of spurts or arrests, or of changes in apparent brightness? Might these irregularities be only apparent? Might they appear in scholastic achievement without being occasioned by similar variations in mental development?

13. Is it your experience that the more intelligent people are more or less socially adaptable? How would you explain the exceptional cases?

14. How might intelligence tests be used in vocational guidance?

15. When a child's I.Q. becomes higher or lower on a retest, does it necessarily mean that his intelligence has changed correspondingly?

REFERENCES

A general account of the Stanford Revision of the Binet tests together with a discussion of intelligence is given by L. M. Terman in *The Measurement of Intelligence,* 1916. More detailed studies of school problems will be found in L. M. Terman, *The Intelligence of School Children,* 1919, and in Ruodlph Pintner, *Intelligence Testing,* 1923.

The use of the Binet Tests in England is described in Cyril Burt, *Mental and Scholastic Tests,* 1921.

The use and results of mental tests in the American Army during the war is described briefly in Yoakum and Yerkes, *Army Mental Tests,* 1920, and more fully in Vol. 15 of the *Memoirs of the National Academy of Science,* 1921, edited by Robert M. Yerkes.

For discussions of "exceptional" children, see HERBERT WOODROW, *Brightness and Dullness in Children,* 1919; G. M. WHIPPLE, *Classes for Gifted Children,* 1919; and L. S. HOLLINGWORTH, *The Psychology of Subnormal Children,* 1920.

CHAPTER XIX

THE MEASUREMENT, ORGANIZATION, AND CORRELATION OF TRAITS

In the preceding chapter we observed various correlations between native mental capacities and achievement in school subjects, vocational success, and social and moral adaptations. The correlations were in some cases low; in others moderate or high; but none perfect. The probability is that even when opportunities to learn and the efficiency of instruction are equal, to account for achievements—both absolute and relative—traits other than intelligence must be considered. But first, how are various forms of achievement to be measured?

The Measurement of Educational Attainments

The need of objective tests and scales for measuring educational achievements is disclosed by the unreliability of subjective judgments of scholastic products. For example: In an experiment, two final examination papers in first year high school composition were graded by 142 English teachers in as many high schools; a final examination in geometry was graded by 114 teachers of mathematics and a final examination in American history by 70 teachers in history—all grading being on a percentage basis. Representative variations in scores are shown in Figure 55. The marks of the first English paper ranged from 64 to 98; of the second from 50 to 98; of the geometry paper from 28 to 92; and of the history papers from

43 to 90. That these variations were not due mainly to differences in standards in different schools has been shown by similar studies of teachers in the same schools and colleges. The deviations are nearly as great. Even

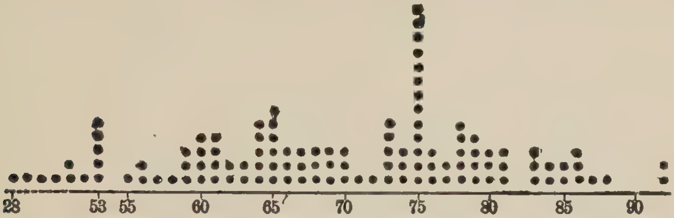


FIGURE 55. Distribution of marks assigned to a final examination paper in geometry by 114 teachers of mathematics. Each dot represents the mark given the paper by one teacher. Marks represent percentages of excellence. (From Starch, *Educational Psychology,* after Starch and Elliott.)

when a teacher after an interval regrades a set of papers, the marks differ appreciably from those of the first scoring.

The causes of such conspicuous variations in grading are many. Teachers have different general standards, lenient or severe, and these may vary considerably from time to time. Different degrees of importance are attached to the many items—penmanship, spelling, grammar, terseness, particular facts, general understanding. Judgments of the relative difficulty of the questions or problems in an examination are often faulty. Among twenty sixth-grade teachers, each of whom judged the relative difficulty of 23 arithmetic problems, there was great disagreement: Problem 1 was placed by some teachers in various positions from the easiest to the eighth in difficulty; problem 12 from the fourth to the seventeenth; and problem 23 from the first to the twenty-first. Familiarity with the work of a group of pupils usually reduces the validity of grading products of those pupils,

some of whom become stamped as generally excellent, others as fair or poor; and these general estimates unwittingly pervade the judgments of the particular tests. The good pupils in general are not marked down as much as they should be when their showing is relatively poor and the poor pupils are not marked up as much as they should be for exceptional performance. All told, subjective judgments of school products are found to be strikingly inaccurate. For more reliable, more comprehensive appraisals of educational attainments there clearly has been a need—a need fulfilled in some measure by standardized and scaled tests.

Any series of questions, exercises or problems constitute a "test." When the procedure for giving a test, the instructions, the time, and the method of scoring the results are prescribed, we have a "standardized test." For many of the standardized tests now in use "scales" have been constructed by the use of which the pupil's achievement may be evaluated. A scale is either a statement of a series of test scores ranging from the lowest to the highest *by steps of known, usually equal magnitude,* or a representation of a series of products which range from very poor to excellent by steps of known, usually equal, magnitude. A few illustrations will make this clear.

Quality Scales.—The Thorndike Writing Scale consists of a series of samples of handwriting ranging from very low to very high quality or merit by equal steps (see Figure 56). A specimen of a pupil's writing obtained under prescribed test conditions is compared with the samples on the scale and given the scale score which it equals in merit. The value of the scale is that it provides an objective standard of comparison and furnishes a device by means of which teachers' estimates may be improved and expressed in terms of a uniform currency.

Scales for judging the merit of English compositions, free-hand drawing, lettering, sewing, and other educa-

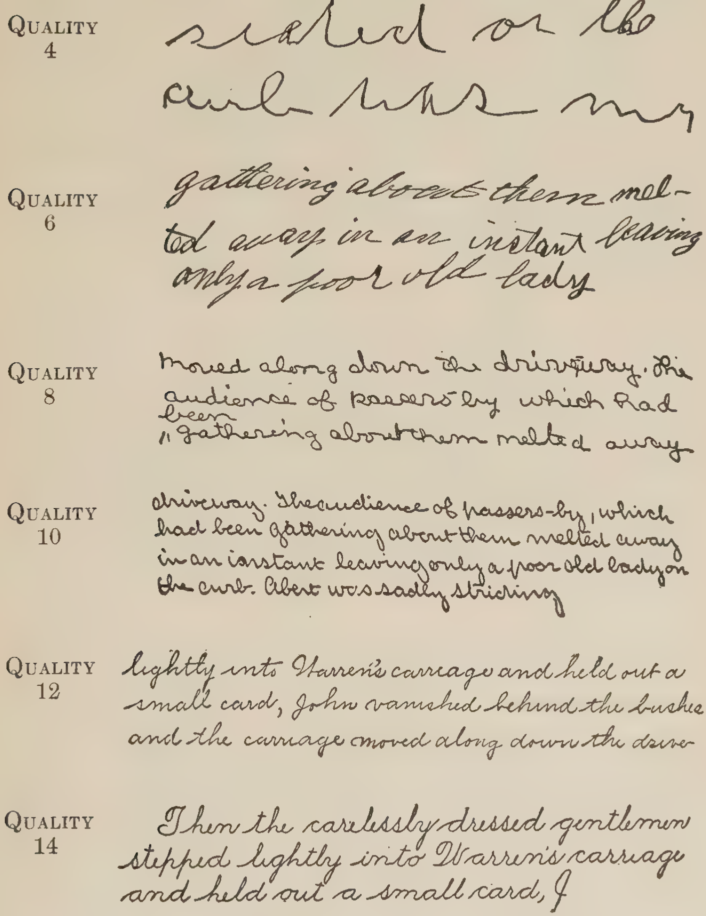


FIGURE 56. Specimens from the Thorndike Scale for Quality of Handwriting. The samples are greatly reduced in size and only a few of the specimens at a few of the steps are shown. The original includes several specimens for each step from Quality 0 to Quality 18.

tional products have been constructed on the same principle.

Difficulty Scales.—The difficulty of a performance, as well as the quality, may also be measured by a scale. The scale in these cases consists of a series of tasks or problems ranging by equal steps from easy to hard—or at least by steps of known magnitude. The pupil begins

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
8	6	2	9	4	11	13	59	78	$7-4=$	76
5	0	1	3	4	7	8	12	37		60

(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
27	16	50	21	270	393	1000	567482	$2\frac{3}{4}-1=$
3	9	25	9	190	178	537	106493	

(21)	(22)	(23)	(24)	(25)	(26)
10.00	$3\frac{1}{2}-\frac{1}{2}=$	80836465	$8\frac{7}{8}$	27	4 yd. 1 ft. 6 in.
3.49		49178036	$5\frac{3}{4}$	$12\frac{5}{8}$	2 yd. 2 ft. 3 in.

(27)	(28)	(29)	(30)
5 yd. 1 ft. 4 in.	$10-6.25=$	$75\frac{3}{4}$	$9.8063-9.019=$
2 yd. 2 ft. 8 in.		$52\frac{1}{4}$	

(31)	(32)	(33)	(34)	(35)
$7.3-3.00081=$	1912 6 mo. 8 da.	$\frac{5}{12}-\frac{2}{10}=$	$6\frac{1}{8}$	$3\frac{7}{8}-1\frac{5}{8}=$
	1910 7 mo. 15 da.		$2\frac{7}{8}$	

FIGURE 57. Woody's Arithmetic Scale, Form A, subtraction. The problems increase in difficulty by steps of known magnitude. This is a "difficulty" scale.

at the easy end of the scale and progresses as far as he can in the time allowed, which is usually liberal. The score is then the scale-equivalent of the most difficult task or problem the pupil can do. The Thorndike-McCall Reading Scale belongs in this category. It measures the degree of difficulty of comprehension in reading. The Woody Arithmetic Tests, which measure the maxi-

mum difficulty of problems that may be solved (see Figure 57), and the Ayres Spelling Scale, which measures the difficulty of words that may be spelled, are constructed on the same principle.

Speed Scales.—Another type of scale affords a measure of the amount of work of a uniform quality and difficulty a subject can do in a prescribed time. The Courtis Arithmetic Tests are of this type. They consist of a series of problems of equal difficulty. The score is the

These ducks are out walking on a cold winter day. The black duck is ahead; but she is unhappy because the cold snow hurts her feet. Make one short line under her feet to represent a board for her to stand on. Then make one more short line for the white duck to stand on. Now both ducks will keep their feet warm.

FIGURE 58. A sample passage from the Burgess Reading Test. The whole test consists of 20 passages of this type, all of approximately equal difficulty. This is a "speed" test.

number of problems correctly solved in a prescribed time. The Burgess Reading Test, which is also a speed test, measures the number of paragraphs read and correctly interpreted in a given time (see Figure 58).

The purpose of the standardized test is to enable the teacher to do better what already she desires to do but can otherwise accomplish only with difficulty, if at all; that is, to determine with exactitude—independent of subjective bias—the speed, difficulty, or quality of the pupil's achievements. Using the same tests and

standardized methods of giving and scoring, norms of attainments for the various ages and grades may be constructed with which the competence of individual pupils or groups may be compared. The instruments may be used in school surveys, in classification and grading, in definition of standards of achievement, in evaluating the methods of instruction, in the encouragement of progress, in the diagnosis of individual difficulties, and in the solution of other problems which school teachers or administrators encounter.

Special Aptitudes and Inaptitudes

With the application of standardized tests and scales to children of similar general mental ability, it became apparent that even among functions which gave about equal correlations with intelligence tests, considerable variations occurred. That is, although reading, composition, arithmetic, spelling, history, and other linguistic and abstract subjects were on the whole closely and fairly uniformly associated with general capacity as measured by an intelligence test, most individual children portrayed particular strengths and weaknesses. These variations are shown in the fact that the correlations of these subjects with each other are far from perfect, as disclosed in the following table:

Correlations Between Various Subjects in a Group of 55 Children from Grade 5 (From Gates, Unpublished Data)

	Reading	Arithmetic Difficulty	Arithmetic Facility	Composition	Spelling
Reading	..	.48	.44	.52	.48
Arithmetic difficulty	.48	..	.65	.43	.33
Arithmetic facility	.44	.65	..	.42	.36
Composition	.52	.43	.42	..	.52
Spelling	.48	.33	.36	.52	..

Similar results are found among skills. Thus, among a group of fifth and sixth grade children, writing and drawing were correlated to a degree indicated by + .50.

The way in which representative children vary in closely related functions is shown in the graphs (Figures

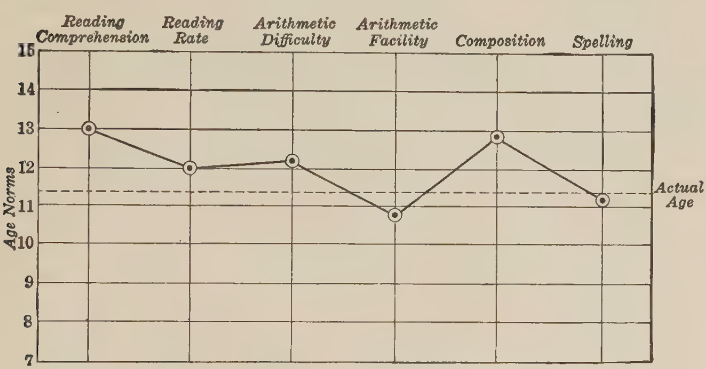


FIGURE 59. An educational "profile." The dotted line shows the pupil's actual age. The vertical column at the left gives the "norms" or average scores for ages 7 to 15. This pupil is as good as the average 13-year-old in comprehension in reading, or, we may say he has a "reading comprehension age of 13 years." He is at age 12 in reading rate, a little above 12 in the degree of difficulty of arithmetic problems which he can solve, less than 11 in speed and facility in arithmetical operations, nearly 13 in composition but barely above 11 in spelling. This profile shows about an average amount of irregularity in achievement.

59, 60, 61 and 62). Whether the average competence along a general line is low, average, or high, there appear variations in ability along special lines. Occasionally, an individual shows a wide departure from his own average, such as a special aptitude for mathematics or a conspicuous backwardness in spelling.

Specializations do appear. How are they occasioned? There is considerable evidence that they are to be explained in part by differences in native capacity for achievement along specific lines. The evidence in favor

of this belief is much the same as that which indicates the inheritance of general mental ability. Special aptitudes

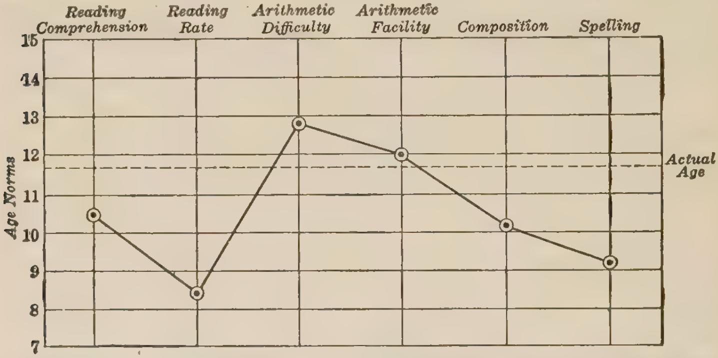


FIGURE 60. An irregular profile which shows unusual backwardness in reading and other linguistic abilities with average ability in arithmetic.

for composition, mathematics, and spelling, or for music, drawing, or carpentry appear when environment and training and general competence have been similar.

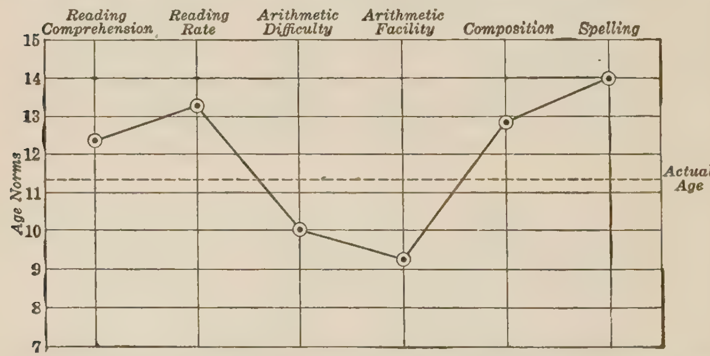


FIGURE 61. An unusually irregular profile which shows decided backwardness in arithmetic with better than average ability in reading and other linguistic subjects.

Special difficulties or "disabilities" in spelling, reading, drawing, etc., are occasionally found that can scarcely be removed even by unusual instruction and effort. Finally,

special aptitudes and inaptitudes often run in families as the studies of the inheritance of individuals eminent in music, painting, or mathematics, or possessing specific defects and deficiencies, have shown.

Each individual, then, has to some extent specialized native capacities. In several fields tests for these native aptitudes have been or are being constructed, although few have as yet reached a stage of usefulness comparable with that attained by the Binet scale for measuring gen-

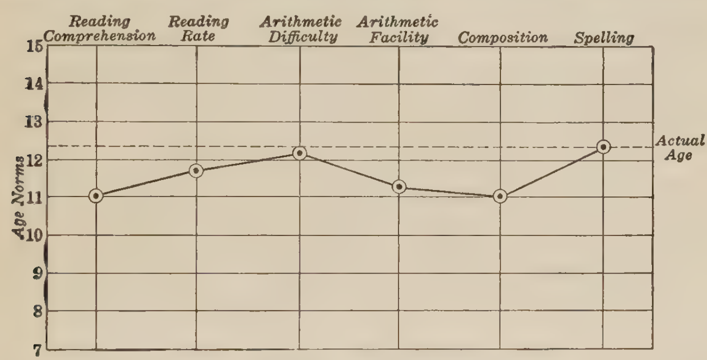


FIGURE 62. A very uniform profile but averaging a little low for the age of the pupil.

eral mental capacity. Of the several efforts, Seashore's Tests of Musical Talent represents the most promising advance.

THE CAUSES OF DISCREPANCIES BETWEEN CAPACITY AND ACHIEVEMENT

The *possibilities* of achievement, then, depend mainly upon native capacities for learning along the particular line in question. But between competence and capacity, between actual and possible attainments, wide discrepancies are frequently found. How are they to be explained?

First, by inequalities of opportunity and instruction. Mere capacity does not insure achievement. Achievement is the return on capacity wisely invested in education.

Even when age, opportunities to learn, and the proficiency of teaching are rendered as nearly equal as possible, gaps between capacity and achievement will still be found. To account for them would usually demand a complete appraisement of the individual's equipment. It would be necessary to diagnose the efficiency of the sensory mechanisms and the organs of response, the regulative glands, the stage of anatomical and physiological maturity, the strengths of numerous instinctive tendencies, the general and particular emotional propensities, the stability of nervous control, the nature of habits previously acquired, and various complex traits such as diligence, trustworthiness, ambition, and sociability.

The importance of some of these traits has been indicated in previous chapters. Some of them may now be measured with considerable precision; but in the appraisal of others only a beginning has been made. Within the limits of this book only a brief discussion of the efforts to devise measures for a few of the more complex traits is all that can be attempted.

Measurement of General Emotionality, Nervous and Mental Stability

What is meant by general emotionality, nervous and mental stability, and how they are related to achievement and general adjustment to life was described in Chapters VIII and IX. There are theoretical and practical distinctions between general emotionality, instability of the nervous type and instability of the mental, which may be discovered by expert diagnosis; but for prelim-

inary appraisement in practical hands tests for general, undifferentiated deviations from the average stability are alone available. Of these the Woodworth-Mathews Psychoneurotic Questionnaire (an outgrowth of Woodworth's Questionnaire developed for adults during the War) is a promising instrument for use with children. It consists of two series of questions, one primarily for pre-adolescent children and another primarily for adolescents. The two lists together comprise 100 questions, of which the diagnostic significance has been established experimentally. The symptoms fall into four groups: (1) Those relating to fears, worries, perseverating ideas, or acts—for which there are 22 questions; (2) those relating to physical symptoms, such as pains, weariness and incoordinations—25 questions; (3) those relating to unhappiness, unsocial and anti-social moods—37 questions and (4) those relating to dreams, phantasies and sleep disturbances—16 questions. Samples of the questions are given below.

Do other children let you play with them?	Yes	No
Do you ever feel that people are staring at you?	Yes	No
Does it make you uneasy to cross a bridge over water?	Yes	No
Are you afraid of water?	Yes	No
Are you afraid during a thunder storm?	Yes	No
Do you feel like jumping off when you are on a high place?	Yes	No
Are you often frightened in the middle of the night?	Yes	No
Do you ever cry out in your sleep?	Yes	No
Are you troubled with dreams about your play?	Yes	No
Do you ever have the same dream over and over?	Yes	No
Did you ever have the habit of stuttering?	Yes	No
Is there any one kind of food that makes you very sick?	Yes	No
Are your feelings often hurt so badly that you cry?	Yes	No
Can you stand pain as quietly as others do?	Yes	No
Do you sometimes feel that nobody quite understands you?	Yes	No

Among 1034 school children of ages 9 to 19 years, the number of unfavorable responses varied from 2 to 67,

with 23 as an average. Children with psychoneurotic tendencies usually show a relatively large number of unfavorable responses and as a rule the more pronounced the instability the larger the number of symptoms. The correlation was close enough to make it likely that these questionnaires will be of substantial usefulness for a preliminary estimate of general emotional, mental and nervous instability.

Measurement of Instinctive Dispositions

Each of the instincts discussed in Chapter VII offers a clue to the study of personality. Some children are more pugnacious than others; some more obstinate, masterful, or self-assertive; some are more acquisitive, curious, kindly, gregarious, or more prone to laughter, to crying, or to fear; some have stronger sex and parental propensities; some are more zealous to secure social approval; some are more responsive to rivalry. All told, these native dispositions constitute an important stock of dynamic factors which in no small measure contribute to the adjustments to school lessons and to other situations in life. That the task of measuring these traits of personality is not as yet far advanced is substantial evidence not of indifference but of the complexity and difficulty of the tasks involved.

For several traits, such as aggressiveness or self-assertion, perseverance, optimism, stubbornness, and flexibility in adjustment and ambition, tests have been devised and are now being subjected to trial. Among the most ingenious and most promising is the Will-Temperament Test devised by Downey, which includes twelve specific tests, based mainly on handwriting, for such traits as the following: (1) Speed of movement (whether a person naturally moves quickly or slowly); (2) freedom from

load (the tendency to warm up rapidly and work at high pressure without external pressure); (3) flexibility (ease and effectiveness in readjustment or adaptability); (4) speed of decision; (5) motor impulsion (impetuosity and energy of reaction); (6) reaction to contradiction (the degree of confidence with which one maintains his opinion against contradiction); (7) resistance to opposition (the tendency to overcome obstruction); (8) finality of judgment (whether one wavers or perseveres in his opinions); (9) motor inhibition (a test of "motor control, imperturbability, and patience"); (10) interest in detail; (11) co-ordination of impulses ("capacity to handle a complex situation successfully without forgetting any of the factors involved"); and (12) volitional perseveration ("willingness to keep plugging away").

Downey's method is to use the scores for each test independently, displaying them for purposes of comparison in a graph which portrays the will-temperament "profile." Figure 63 gives a sample profile. A balanced profile running from scores 4 to 6, according to Downey, suggests a less speedy, forceful, and accurate individual than a profile ranging from 8 to 10. High scores on such traits as speed of movement and decision, freedom from load, flexibility, and motor impulsion are said to characterize an individual as mobile or rapid-fire in organization, whereas high scores in motor inhibition, interest in detail, co-ordination of impulses and volitional perseveration are characteristic of the controlled, deliberate, painstaking person. Many combinations are possible among the twelve tests but they are not so numerous as to exaggerate the multiplicity of temperaments found in human nature.

How faithfully the Will-Temperament Tests represent the traits they purport to measure has not as yet been

determined with finality, but the tests have opened a fruitful field for research, out of which objective measures of many important dynamic traits will sooner or later

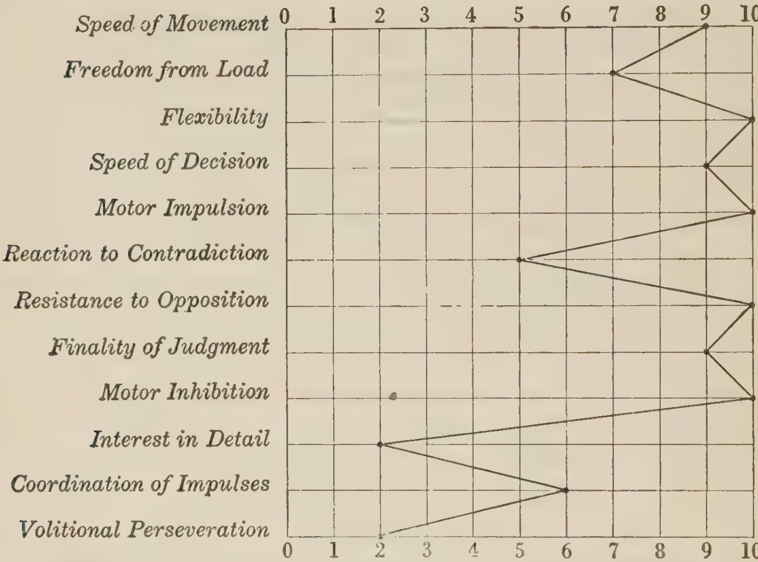


FIGURE 63. The Will-Temperament Profile of an adult who "has held a number of important executive positions. He is, in addition, an effective public speaker and possesses great dramatic talent. His profile suggests, in general, the type of the successful administrator, especially with reference to the high scores for speed of decision, finality of judgment, freedom from load, resistance to opposition and motor impulsion in conjunction with high motor inhibition. The high score for flexibility and the medium one on reaction to contradiction (tactful response) indicate social pliability and suggestibility which increase X's social assets, but are of dubious value in his business life. The low score on interest in detail is not a serious defect, since X is in a position to turn over to subordinates the execution of many of his projects. It goes, however, with a tendency to generalize on insufficient grounds. The low score on volitional perseveration is probably a real weakness." (Graph and Quotation from Downey. *Manual of Directions,* copyright 1921, published by the World Book Company.)

result. As the validity of such tests is demonstrated, the rôle of temperamental and volitional traits in school and society will be more perfectly determined.

Subjective Judgments of Human Traits

Where tests are not available, resort to judgments based on observation is the common alternative. How unreliable are judgments of human traits has been demonstrated in many experiments. For example, near the end of the school year, the teachers of a small school were asked to judge the "school attitude"—to make a general judgment of the interest, diligence, and willingness to work—of those pupils with whom they were well acquainted. Each teacher utilized the same description of the trait in question and the same device for recording her judgment. Between the judgments made by any two teachers, we may compute coefficients of correlation which portray the degree to which the two teachers were in agreement. For twenty-one such comparisons, the correlations are as follows: .04, .10, .16, .19, .27, .31, .31, .35, .38, .39, .47, .48, .50, .54, .55, .55, .56, . 58, .62, .70, .75. The median of the series is .47.

These figures show a range from almost no agreement to very substantial agreement; the median being but fair agreement. Conceivably, judgment is not as bad in the extreme cases as these data appear to show since some pupils may show a good attitude toward the work of certain teachers and a poor attitude toward that of others. These differences would perhaps hardly obtain so pronouncedly in the case of such traits as neatness, sagacity, humor, conceit, and refinement which likewise provoke disagreements among judges.

Many investigators have sought to reduce the unreliability of judgments of human traits by the use of rating scales, of which there are many varieties. During the World War, psychologists introduced into the army for the use of officers a rating scale which required a "man-

to-man comparison." This scale was constructed by the placing at the upper extreme the name of the man who among the officer's acquaintances ranked highest in the trait in question; at the lower extreme the name of the man lowest in the trait; at the middle point, an average man; half way between top and middle a fourth man and a fifth half way between the middle and the bottom. Each candidate for judgment was compared with the other men constituting the steps of the scale. While this device doubtless increased somewhat the validity of judgment, a high degree of accuracy was not obtained. If judgment of human traits is fallible, as it most conspicuously is, no rating device will make it even approximately perfect. According to an army investigation reported by Rugg, ratings become practicable only when: (1) the rating scales are made comparable and equivalent; (2) the judges are thoroughly acquainted with the subjects; and (3) the independent ratings of at least three judges are averaged.

By whatever device ratings may be guided, some traits are more accurately judged than others—as shown in early experiments by Cattell and Norsworthy, whose results are consolidated below in a table which gives the relative amount of divergence or disagreement among various judges.

Variations in Judgments on Traits as Listed, in Which 100.0 Is the Average Divergence (Quoted from Hollingworth)

TRAIT	RELATIVE DISAGREEMENT
Efficiency	83.7 (closest agreement)
Originality	86.2
Quickness	89.0
Perseverance	88.1 (close agreement)
Judgment	89.4
Will	91.8

TRAIT	RELATIVE DISAGREEMENT
Mental balance	96.0
Intensity	99.4 (average agreement)
Independence	101.7
Coöperativeness	119.3 (very little agreement)
Cheerfulness	121.0
Kindliness	122.9

The personal and social traits such as kindliness, cheerfulness, and coöperativeness are most poorly judged as indicated by the fact that disagreements are here very great. Traits for which objective evidence is more readily available are the most reliably judged, e.g., efficiency, originality and quickness, which disclose themselves more obviously in the products of daily work. Judgment, will, intensity, and independence fall between the extremes, at levels which probably indicate the degree to which the evidence whereby individuals may be judged is impersonal.

One difficulty common to teachers and others in the judgment of traits is the tendency to form a judgment of a person as a whole, as very good, average, or poor—which often, unintentionally, influences the judgment of each particular trait. At some we look through the small and at others through the large end of the telescope, which presents to our eyes an expanded or compressed personality in whole and in all its parts. Where objective measurements are unavailable or inadequate, the practical worker and the investigator alike should treat subjective estimates with caution.

The Organization of Traits into Personalities

What traits constitute a person—as far as his general adjustments and activities in the everyday give-and-take relations are concerned—we have attempted to disclose in some measure; but heretofore many traits have been con-

sidered in isolation from others. The practical influence of a given trait is often determined not wholly by its amount but also by its relation to others. Other things being equal, a high degree of intelligence is more productive when found in a healthy body. A powerful voice alone will not make a successful statesman, nor will a fine physique. The race is not always won by mere swiftness. For many forms of adjustment and achievement, a certain *combination* of traits is required.

Personality Types.—It has been customary to divide individuals into "types" of personality. By a "type" we should properly refer to the kind of individuals that are most numerous, to those that are most typical of the whole group. But mainly the customary "types" of personality or temperament—such as the sanguine, choleric, phlegmatic, and melancholic—refer to the extreme rather than to the typical organizations of human traits. This is probably due partly to the over-estimation of the frequency of the extreme cases and to a failure to observe that the largest numbers are clustered about the average. The exceptional cases attract attention precisely because they are exceptions. And the tendency to classify people sharply into personality types usually distorts the picture of distribution by producing large groups at the extremes where actually these are few, and few people at the average, where really there are many. In comparing the personalities of *groups*, consequently, the emphasis on the extremes usually results in an exaggeration of the differences between the groups as a whole.

Sex Differences

If we were to attempt to divide the human race into types of personalities, no grouping could be more obvious and if popular opinion were reliable, no groups more

conspicuously different than male and female. In fiction and in pseudo-scientific literature, sex differences are described in number and degree so great as to make man and woman appear to be members of nearly distinct species. This is doubtless due in part to a tendency to compare extreme cases of the two groups, and it may be said at the outset that while sex differences do exist, they are less great than has generally been supposed. Before considering male and female personalities as a whole, it will be necessary to consider the differences in specific traits. In gross physical traits—height, contour, weight, strength, and appearance—sex differences are most spectacular, a fact which doubtless has had an influence on the judgments of mental and temperamental traits. But even in physical traits, the overlapping of boys and girls of the same age, or of men and women, is considerable.

At maturity boys excel girls in height, weight, strength, lung capacity, and other physical capacities. Of considerable educational significance is the fact that girls are more precocious in their anatomical and physiological development. The following table gives a rough indication of the facts:

Percentage of Final Growth at 17 Years That Has Been Attained at 7 and 12 Years of Age (After Baldwin)

TRAIT	SEX	AT 7 YEARS	AT 12 YEARS
Height	Boys	70.3%	83.8%
	Girls	74.2	90.0
Weight	Boys	38.7	60.1
	Girls	40.9	68.2
Strength of	Boys	27.8	52.5
Right Arm	Girls	34.9	68.4

At 7 years of age the girls have outstripped the boys in their progress toward maturity and they increase their lead to a maximum in the vicinity of the twelfth year,

where their advantage amounts to about the equivalent of two years, i.e., the eleven-year-old girl has the maturity of the thirteen-year-old boy. Beginning at about twelve, the girl's growth tapers in comparison with the boy's, whose development is rapid until the seventeenth year, when final maturity is or has been reached by the majority of both sexes.

These differences in physiological age before maturity color the whole personality to some extent. According to Baldwin, "The physiologically more mature child has different attitudes, different types of emotions, different interests, than the child who is physically younger though of the same chronological age" . . . "there is a direct relationship between social age and physiological maturity." "Some at a given chronological age are sufficiently mature to meet the social conditions which may arise, while others are not."[1]

In general intelligence sex differences are less conspicuous at all stages of growth, as is shown in the following table based on the Binet Mental Ages of 1000 children measured by Terman and 3500 measured by Burt.

Difference in Mental Age (Years) in Favor of Girls

Average Chronological Age	Terman	Burt
5.5	0.22	0.4
6.5	0.39	0.6
7.5	0.15	0.5
8.5	0.17	0.3
9.5	0.38	0.4
10.5	0.00	−0.3
11.5	0.56	0.1
12.5	0.25	0.4
13.5	0.14	0.4
14.5	0.58	0.7
Average	0.284	0.35

[1] Baldwin, *Physical Growth of Children,* pp. 195-197.

Both investigations agree that the girls surpass the boys on the average by about three-tenths of a year in mental age, but the superiority is irregularly distributed. It has been customary to see in these figures a more rapid mental maturation of girls to harmonize with their more precocious physical development, but even if this interpretation is correct—it is not altogether certain that it is—the significant matter is the closeness of the approximation of the two sexes to equality.

In more specific mental abilities—perception, memory, reason, etc.—the difference between the sexes, where they exist at all, are so slight and unobtrusive as to appear dwarfed and swamped in comparison with the immensity of the variation within either sex.

In special aptitudes for various types of school work, sex differences again appear to be slight. Using a battery of standardized tests for reading, vocabulary, arithmetic, spelling, composition, writing, drawing, and handwork, Burt has measured over 5000 school children in 19 different schools, yielding for each age approximately 750 representatives of each sex. The facts are given in the accompanying table which displays the relative attainments of each. On the whole, the differences are essentially negligible. Girls excel slightly in reading, spelling, writing, and composition; boys in arithmetic and handwork; in drawing the sexes are equal. How insignificant are the differences in general is disclosed by the data for arithmetic. In addition girls are slightly superior, in subtraction boys excel, in multiplication attainments are equal, and in division boys excel slightly. All through the list, the sexes play a veritable leap-frog with each other and even in handwork the differences are so small as to be statistically unreliable. On the whole, with equal incentives there is little justification for the as-

sumption of sex differences in capacities for achievement in school functions.

The Average Scores for Boys and Girls of the Same Average Age (From Burt)

	*Reading speed (seconds)	Reading comprehension questions answered	Spelling words correct	Addition number correct	Subtraction number correct	Multiplication number correct	Division number correct
Boys	117	11.3	53.6	21.1	41.0	40.7	29.9
Girls	112	11.6	56.4	21.4	39.7	40.9	29.1

	Writing letters in two minutes	Writing quality	Drawing quality	*Handwork speed (seconds)	Handwork quality	Composition quality
Boys	117.2	9.8	10.0	54.6	10.8	10.6
Girls	125.2	10.1	9.9	55.7	10.2	11.4

(Scores marked * are given in terms of seconds—the smaller figure therefore indicates the better performance.)

Concerning sex differences in instinctive, emotional, temperamental, moral, and other traits innumerable opinions have been given; but for none is there unquestionable evidence. Indeed, as more precise measurement becomes possible the verdict of "no significant difference" is more frequently cast, although it may be that in the traits as yet unmeasured important differences will be disclosed. The most probable differences are certain instinctive and emotional propensities clustering around the differences in reproductive functions on the one hand, and the differences in physical prowess on the other. It is conceivable, but not proved, that the maternal instinct differs in strength and in operation from the paternal, resulting for the woman in a keener interest, broader sympathies, and perhaps clearer insight in dealing with human expressions and acts. Men may be more self-assertive and pugnacious, in keeping with their superior physical strength.

Differences in general achievement and personality between the sexes, then, insofar as environmental influences affect them equally, are doubtless exaggerated by

the tendency to compare the extremes rather than the typical cases. The general differences which do obtain are to be explained not so much by differences in all single traits as by the influence of a few which color the whole. Thus, if the parental instinct is stronger in women, it may affect widely their activities in and relations to life. The superior physical strength of men—and if genuine, the greater force of the pugnacious instinct—would account in part for their greater achievements, even if the mental and motor aptitudes of the sexes were equal.

Racial Differences

Different races offer another opportunity to study combinations of traits. Among civilized races differences in physical traits are demonstrated; differences in temperamental traits are probable, but not demonstrated; and differences in mentality are neither demonstrated nor probable. Extensive measures by various forms of the Binet test in France, Germany, Sweden, England, and America, and less extensive investigation in other countries, show inconspicuous variations in general outcome; the probability is that the general mental ability of these races is approximately equal. In America, little has been learned of racial differences, except that on such tests as the Army Alpha, negroes and Indians perform relatively poorly; but any sweeping statement of the intellectual status of these races would be premature. Among other races in America, insofar as traits have been measured, the overlapping is very great, both in physical and mental characteristics. Concerning emotional and temperamental traits, there is little to offer except conjecture. It is quite likely, however, that the tendency to seize upon some one or few peculiarities of a race, magnify them,

and judge the whole personality in the light of them, results in an exaggeration of the differences between races as a whole.

The Correlations of Traits

If we compare an individual with others of the same age, race, and sex we will find variations above and below a certain central tendency for that individual. This fact has already been mentioned in the case of the school subjects. A pupil who is about average in general is likely to be more or less above average in some subjects and more or less below in others. Another who in general stands high also shows an irregular profile. The same fact obtains in other traits, as may be seen in the profiles in Figures 59, 60, 61 and 62. How great these variations are, which traits tend to be closely associated and which tend to be inversely related, may be determined by computing the correlations between them in the case of a group of individuals.

Studies of the correlations of human traits early disclosed the fallacy of the prevalent belief in compensation —the assumption that the possession of certain desirable traits implied the presence of compensating undesirable characteristics. To illustrate: it was frequently asserted that the quick learners retain poorly, that the rapid workers were inaccurate, that great knowledge went with slow wit, that men of great artistic abilities—as in music, painting or literary composition—were usually stupid in practical matters, that scholarly minds were encased in clumsy bodies, that superior intellects were usually coupled with inferior mental stability. To the extent that various desirable traits have been measured, the facts generally favor the theory of positive correlation rather than that of negative correlation or compensation.

If the reader will glance at the various tables of correlations in this book, he will find positive correlations almost exclusively. A few others will be briefly mentioned, taking as samples the correlations of various desirable traits with general mental ability.

Superiority in mental capacities is correlated positively but not closely with desirable physical traits. If we take a large group of individuals of the same age and divide them into two groups on the basis of mental ability, the brighter group will surpass the duller in height, strength, endurance, manual dexterity, and athletic prowess. The brighter group will have fewer defects of the sense organs, nervous system, reacting mechanisms, and internal organs. There will be many exceptions to the general rule among individuals inasmuch as the correlations are usually low. A similar relation between mental ability and physiological efficiency will be found. The indications are that the group superior in mentality will surpass the other in resistance to disease, to drugs such as alcohol, to malnutrition, to exposure, etc.

The correlations of general mental ability with the broader volitional, emotional, æsthetic, social, and temperamental traits are less well known chiefly because these traits have not as yet yielded to precise measurements. The list of correlations in the accompanying table, however, suggest a decided tendency toward positive correlation:

Correlations of Intelligence Quotients and Various Traits in a Group of 150 First Grade Children (After Dickson Quoted from Terman)

Trait	Correlation with I.Q.
Sense of humor	.58
Persistence	.53
Initiative	.53

TRAIT	CORRELATION WITH I.Q.
Will power	.50
Conscientiousness	.48
Personal appearance	.44
Cheerfulness	.43
Physical self-control	.42
Courage	.39
Dependability	.38
Emotional self-control	.29
Unselfishness	.29
Speed	.28

General mental ability, then, is positively associated more or less closely with other desirable traits. If the problem had been taken up from another point of view, such as the correlations of other traits with morality or artistic ability, the same *general* result would have been found; namely, all desirable traits tend to be associated with each other. The correlations are not equal, however, and they are often low. Even a correlation as high as + .90 permits several individuals fairly high in one trait to be fairly low in the other, and vice versa. Specialization there is; we all have our particular strengths and weaknesses. But on the average, weakness in one trait implies weakness in others; mediocrity in one implies mediocrity in others, and strength in one, strength in others.

QUESTIONS AND EXERCISES

1. What is the difference between a *test* and a *standardized test?* A *test* and a *scale?* When we measure a man under *standardized* conditions such as in stocking feet and with back against a wall, giving the results of the measurement in terms of inches, what comprises the test? What the scale?

2. What are the advantages of standardized tests and scales compared to the "essay" examination? How may they be used in the daily work of the school?

3. For purposes of examination, what advantages can you see in using the "True-False" or the "Completion" tests given among

the exercises of earlier chapters over the essay examination? What disadvantages, if any?

4. Which is probably more accurate, a rating on a *quality* or a rating on a *difficulty* scale? Why?

5. What do people usually mean when they speak of a "womanly woman," "a manly man," "a true Irishman," "a typical Frenchman"? Do you know any such individuals?

6. Define exactly what is meant when you describe another indi vidual as having "a good personality," in terms of specific instincts, capacities, and acquired traits.

7. Why do we have less accurate measures for such traits as diligence, ambition, etc., than we have for intelligence? Are these traits more complex, intrinsically more difficult to measure, less important in life, or are there other causes? Draw up a list of possible explanations.

8. Have women accomplished as much as men in the fields of art, literature, or science? How do you account for any discrepancies found? What biological and environmental as well as psychological factors might be important?

9. Is a judgment concerning an individual's cheerfulness usually as valuable as one concerning his efficiency? Why?

10. Which will usually tell you most about an individual's mental equipment, a knowledge of his race or a knowledge of the traits of his parents?

11. Draw a curve of distribution which will show how we distort the facts when we assume that individuals are divided into types.

12. What traits, other than those mentioned in the text, do you think may contribute to success in school work or life? What ones to desirable moral adjustments? To musical ability? To dramatic ability? To executive ability?

13. Among your acquaintances, do desirable traits seem to go together? Try this out by rating them in several traits such as intelligence, personal appearance, health, popularity, and trustworthiness and compare the results with the distributions shown at the end of Chapter XVI. Is the correlation positive or negative?

14. To what practical uses, in education or elsewhere, may the facts of correlation among desirable traits be put? Do they make measures of intelligence more or less significant than would be the case if the correlations among traits were nearly zero?

REFERENCES

On Educational tests: W. S. Monroe, S. C. DeVoss and F. J. Kelley, *Educational Tests and Measurements,* 1917; S. C. Chapman and F. P. Rush, *Scientific Measurement of Classroom Products,* 1917; G. M. Wilson and S. K. Hoke, *How to Measure,* 1921; W. A. McCall, *How to Measure in Education,* 1922; S. W. and L. C. Pressey, *Introduction to the Use of Standard Tests,* 1922.

For tests of sensory, motor and miscellaneous mental abilities see G. M. Whipple, *Manual of Mental and Physical Tests,* Second edition, 2 vols., 1914, 1915.

For a study of one of the special aptitudes, see C. E. Seashore, *Psychology of Musical Talent,* 1919.

For studies of special inaptitudes or "disabilities" see L. S. Hollingworth and C. A. Winford, *The Psychology of Special Disability in Spelling,* 1918, and A. I. Gates, *The Psychology of Reading and Spelling with Special Reference to Disability,* 1922.

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